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Miyano

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[54] **AUTOMATED MACHINE TOOL INCLUDING A PLURALITY OF PROCESSING UNITS AND A SHARED TOOL STOCKER**

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[51] **Int. Cl.**[7] **B23Q 3/155**

[52] **U.S. Cl.** **483/1**; 29/335; 29/39; 483/3; 483/15; 483/24; 483/37; 483/40; 483/51; 483/63

[58] **Field of Search** 483/1, 33, 14, 483/15, 22, 23, 24, 32, 36, 37, 38, 40, 48, 51, 52, 63; 29/35.5, 36, 39, 335

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Assistant Examiner—Christopher Kirkman
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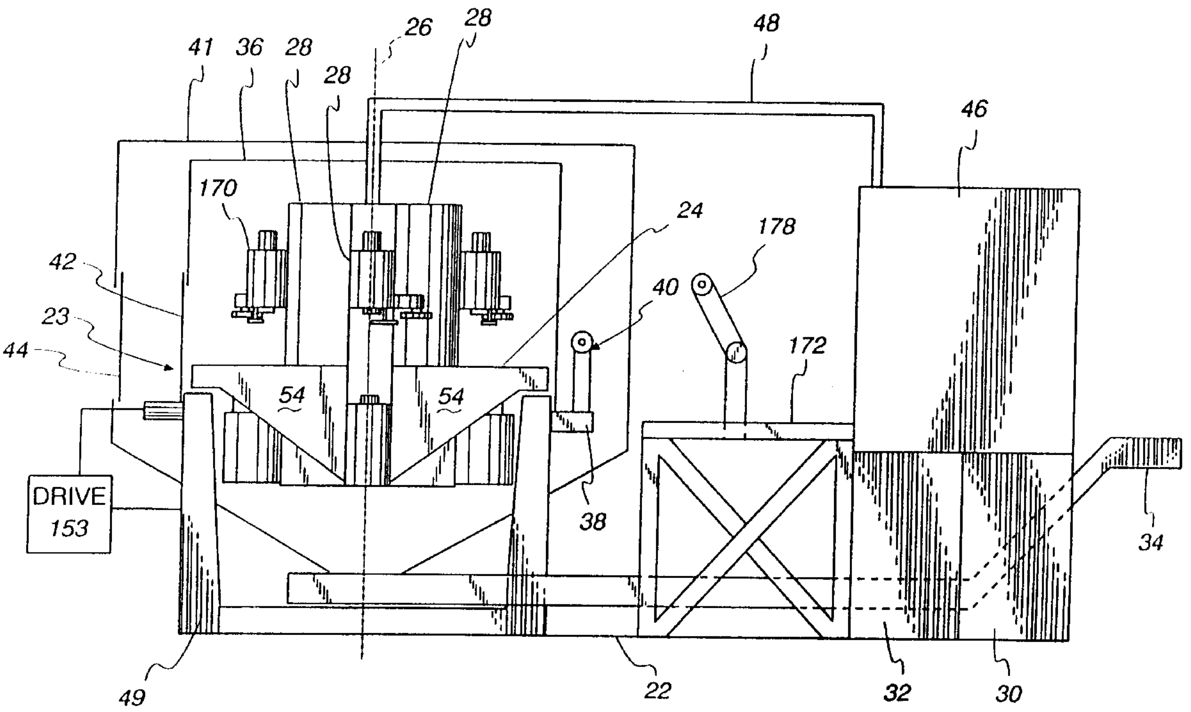
[57] **ABSTRACT**

An automated machine tool is provided and includes a frame having a first workpiece transfer station at a first location on the frame; at least two self-contained processing units, each of the units including structure for holding the workpiece for processing and structure for performing a process on the workpiece; structure for sequentially indexing the processing units to the first workpiece transfer station for transferring workpieces to and from each of the processing units; a shared tool storing device; a first cutting tool transfer device for transferring cutting tools to and from the processing units; and a second cutting tool transfer device for transferring cutting tools between the first transfer device and the storing device.

16 Claims, 7 Drawing Sheets



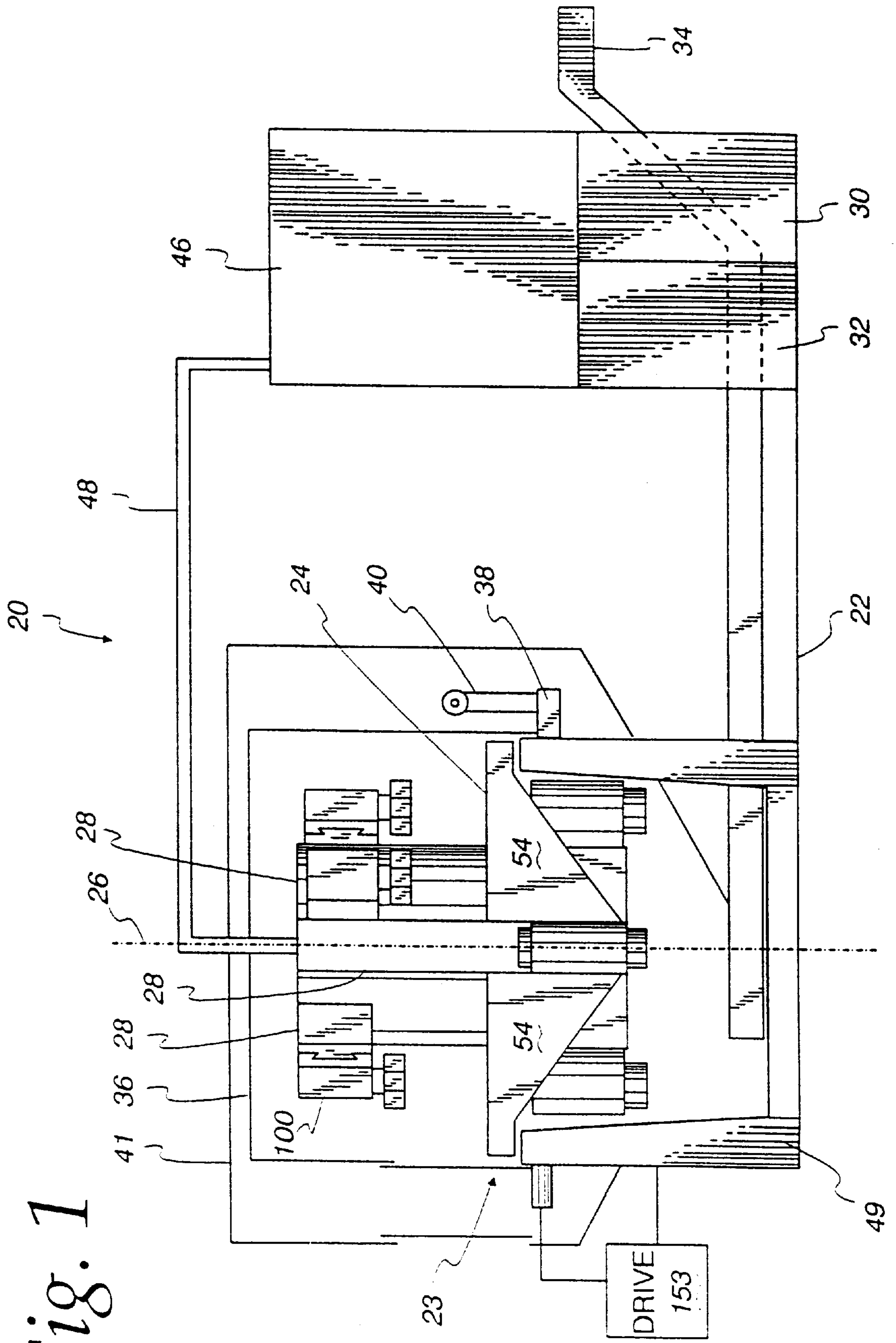

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Fig. 1

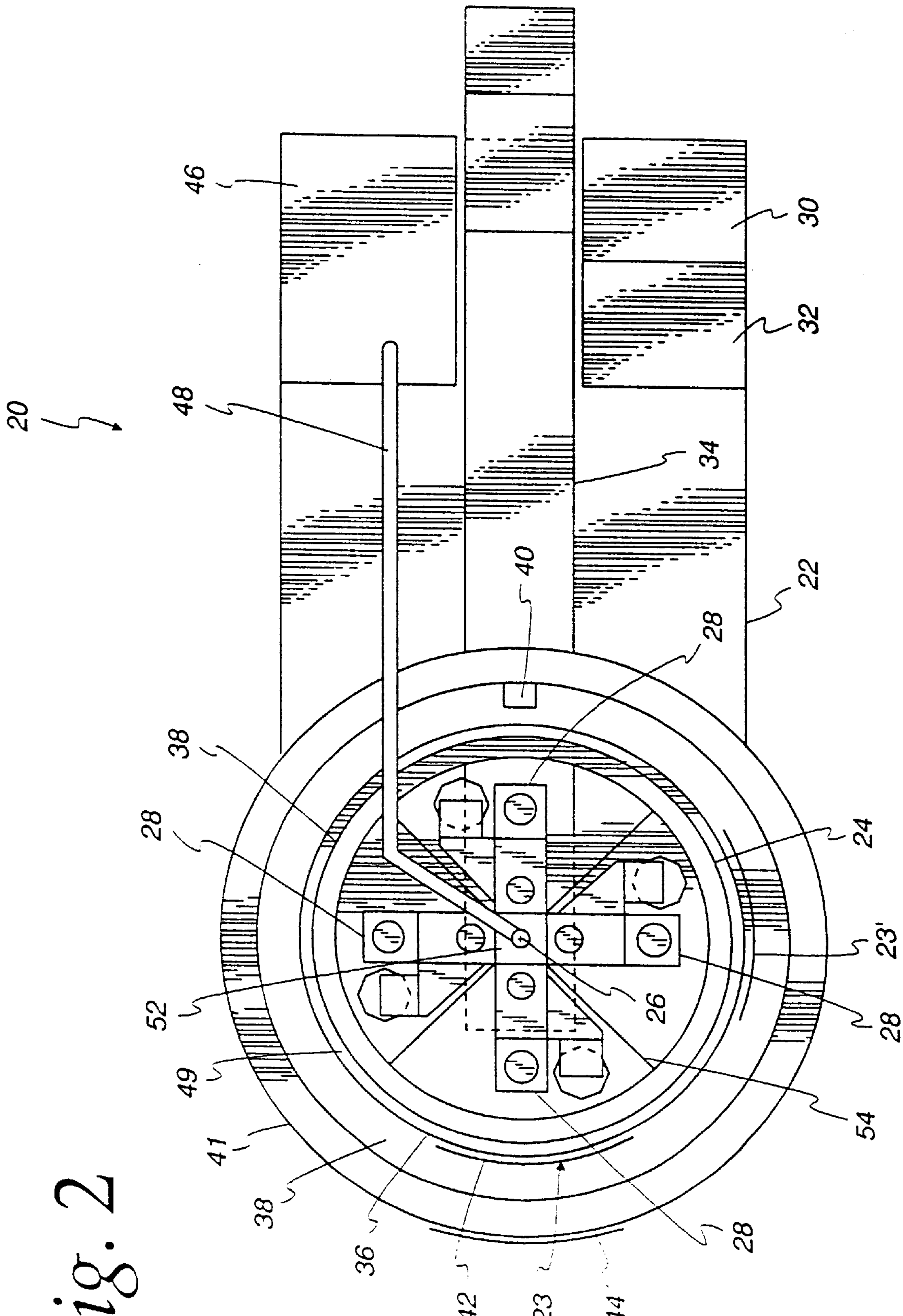
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Fig. 2

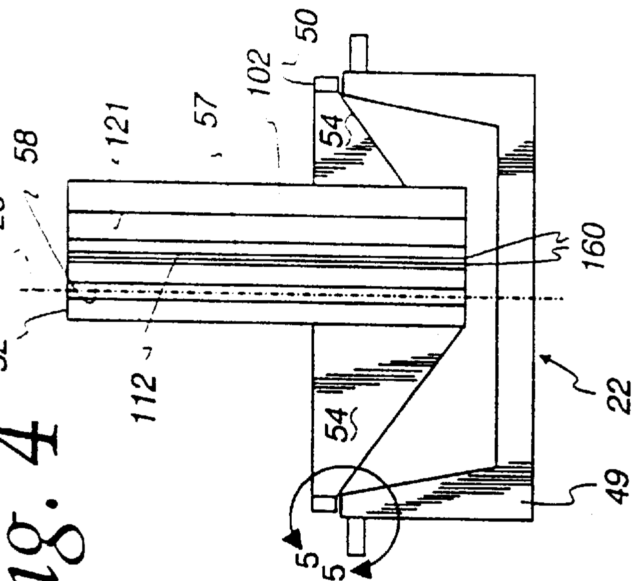

Fig. 4

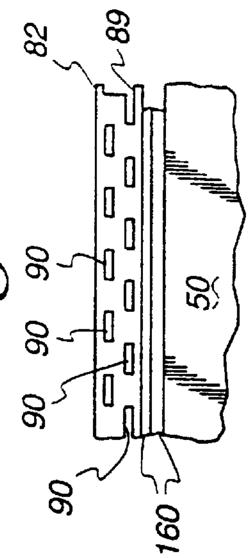

Fig. 7

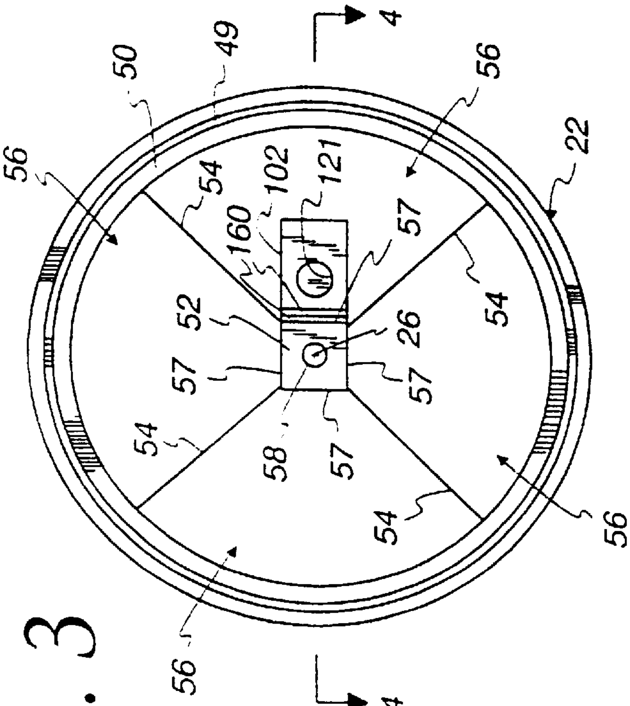

Fig. 3

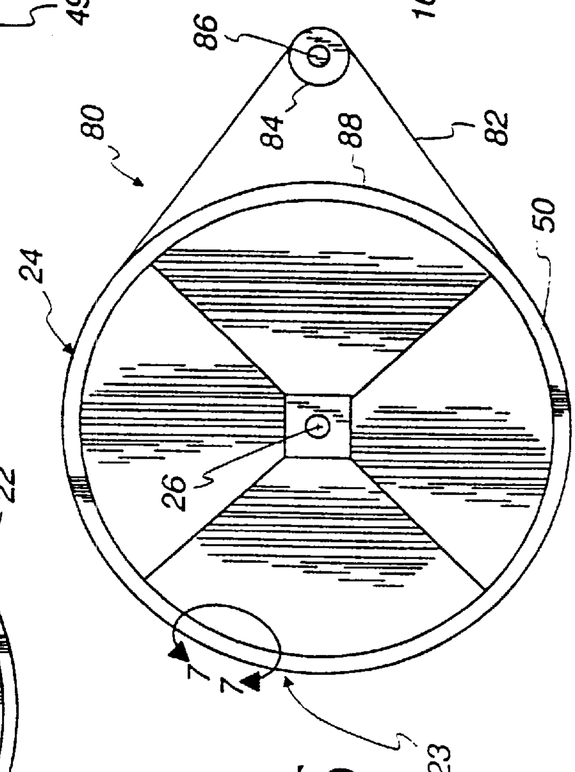

Fig. 6

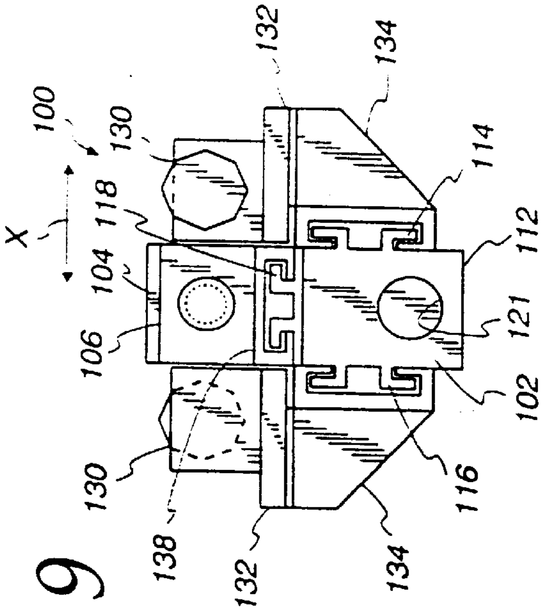

Fig. 9

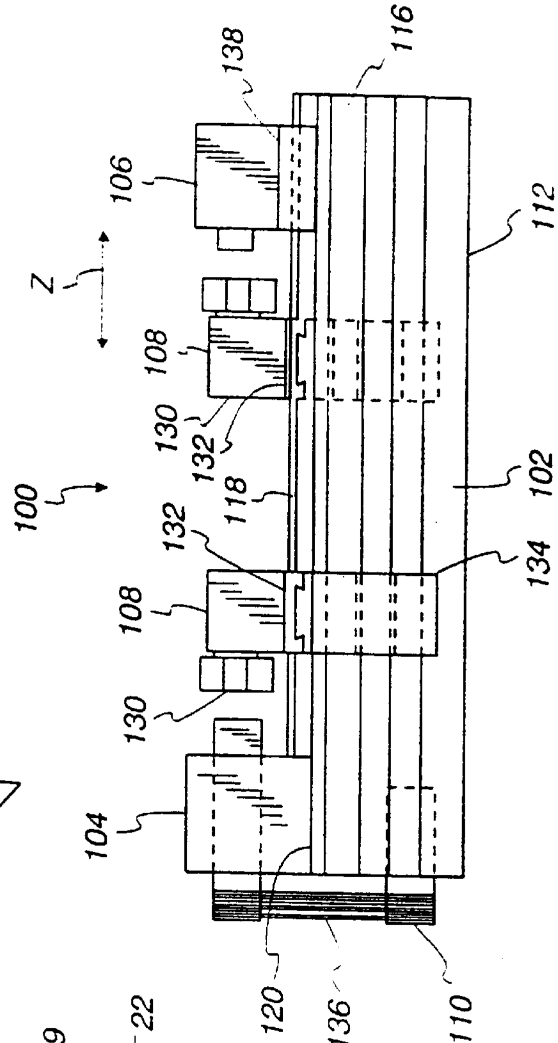

Fig. 8

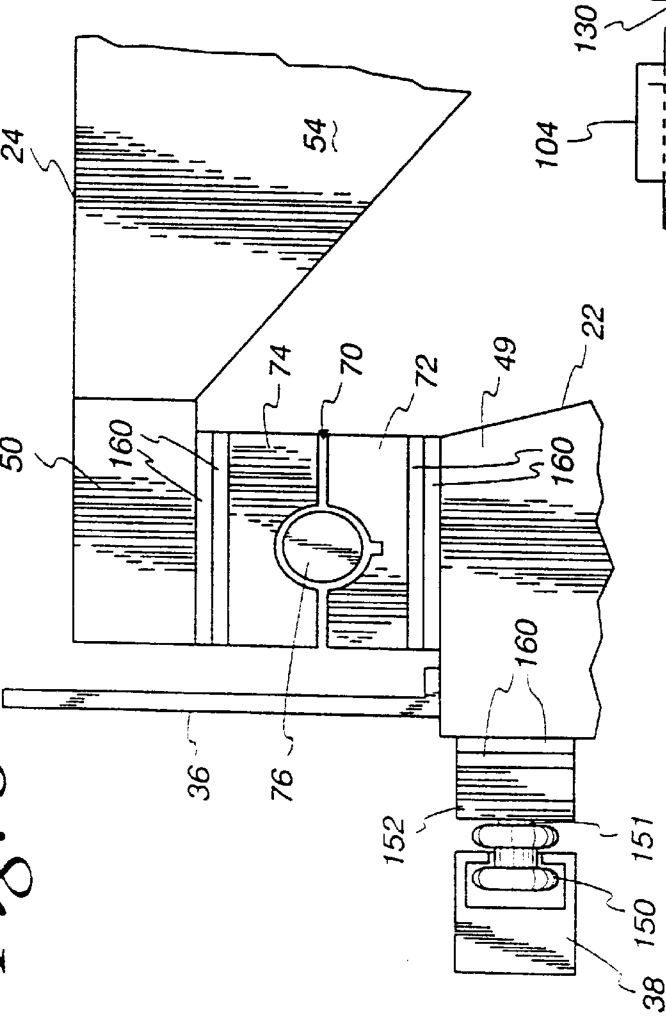

Fig. 5

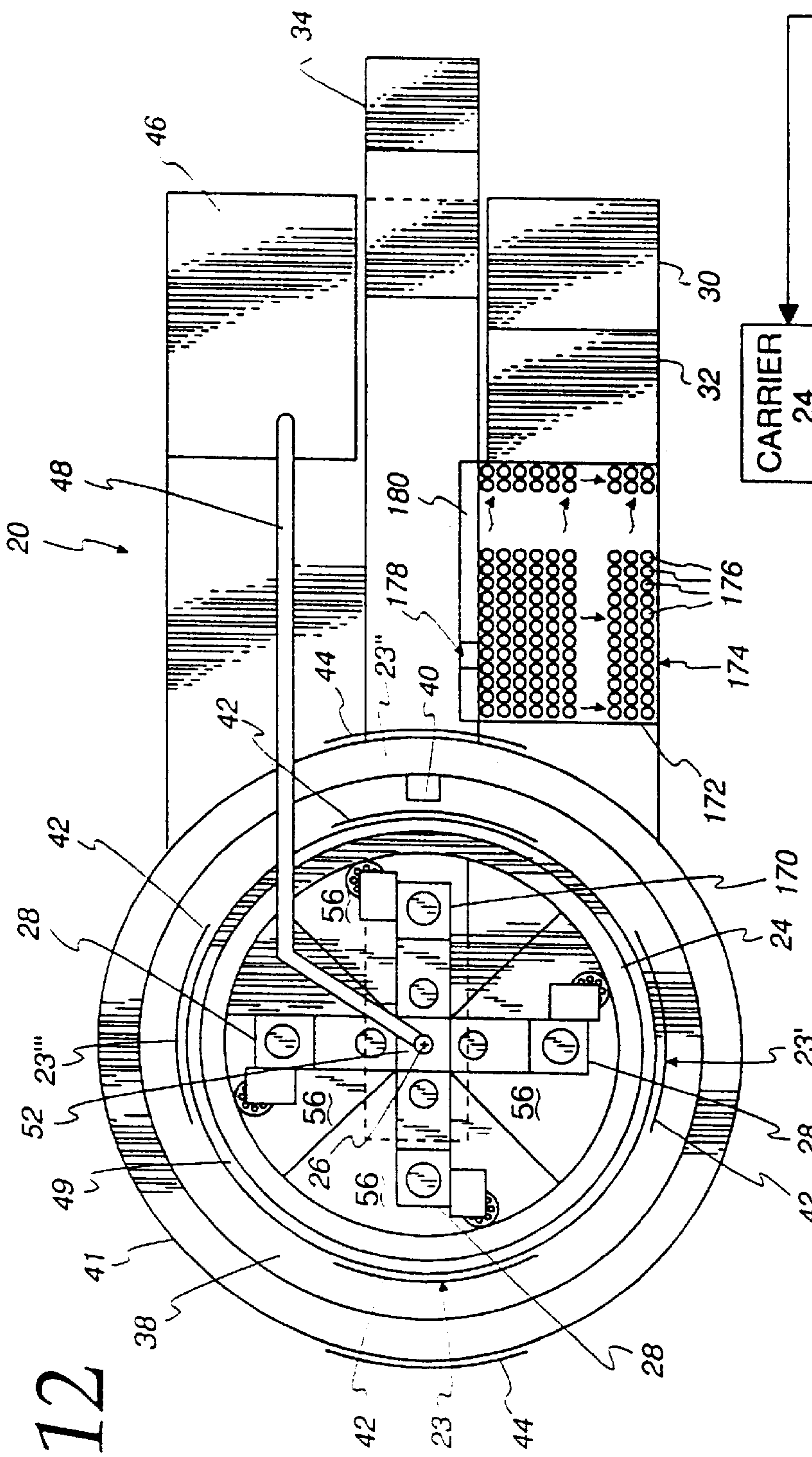

Fig. 12

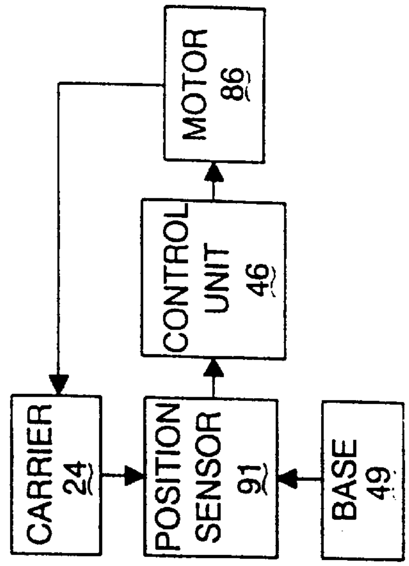

Fig. 10

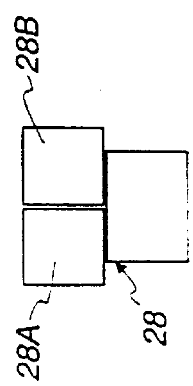

Fig. 11

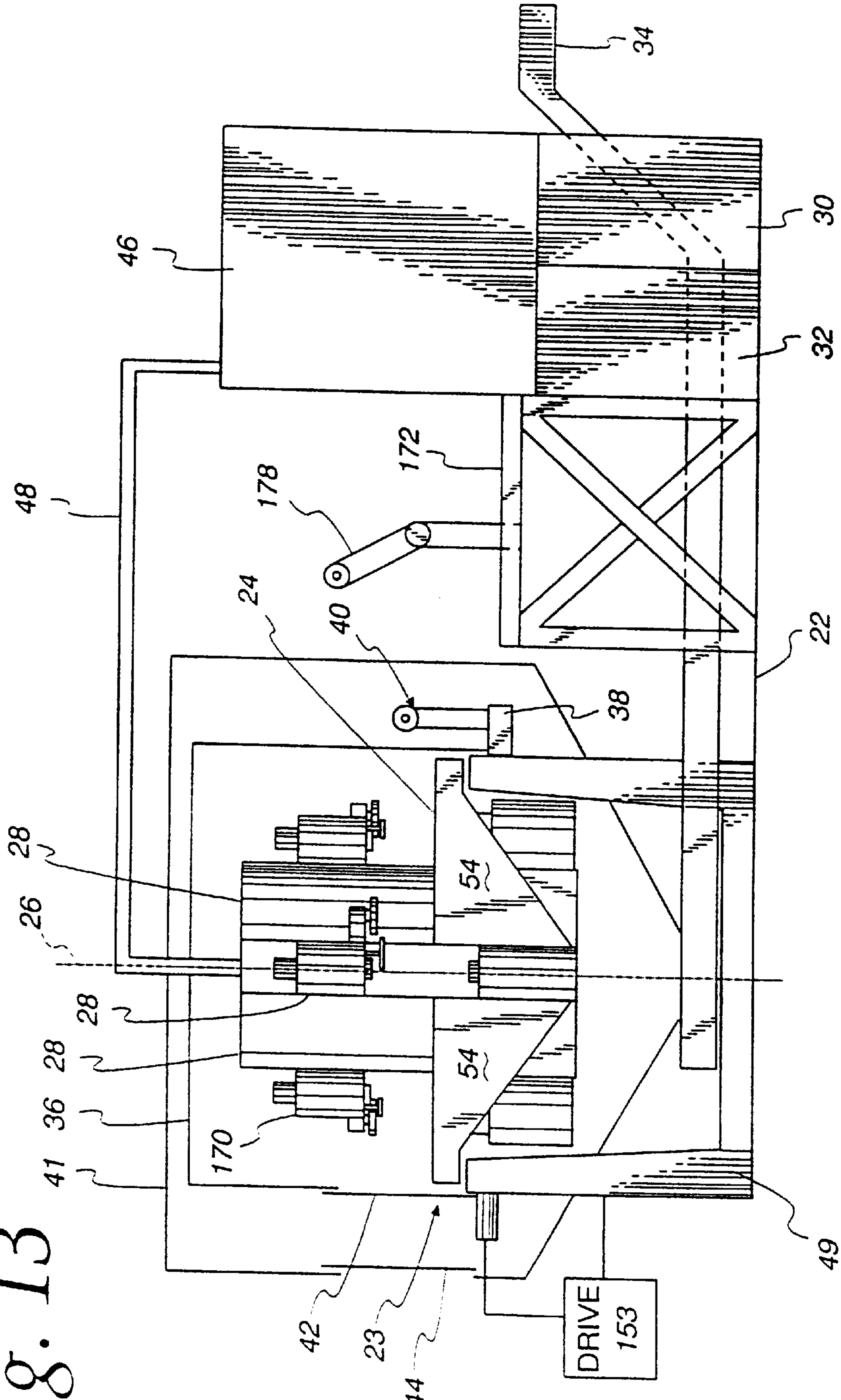
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Fig. 13

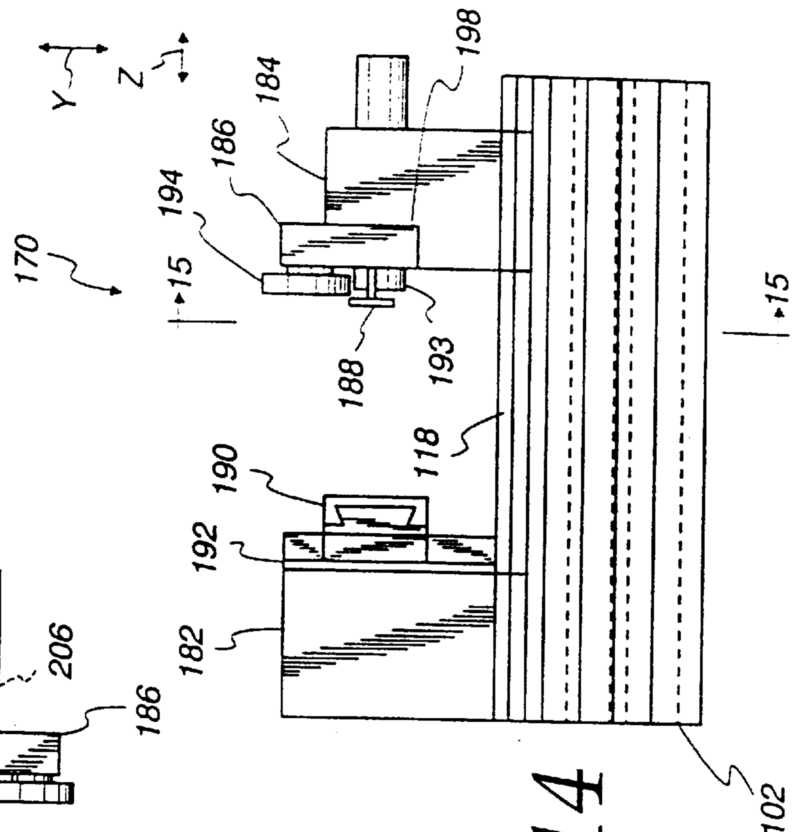

Fig. 14

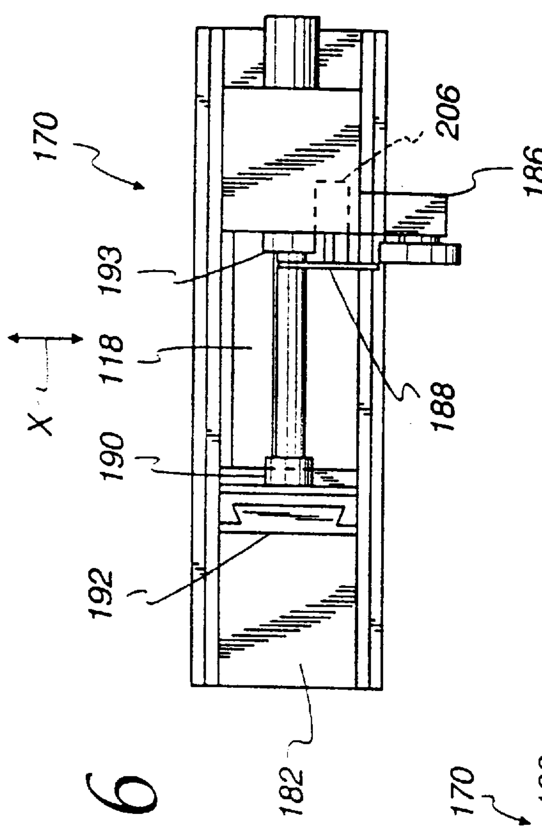

Fig. 16

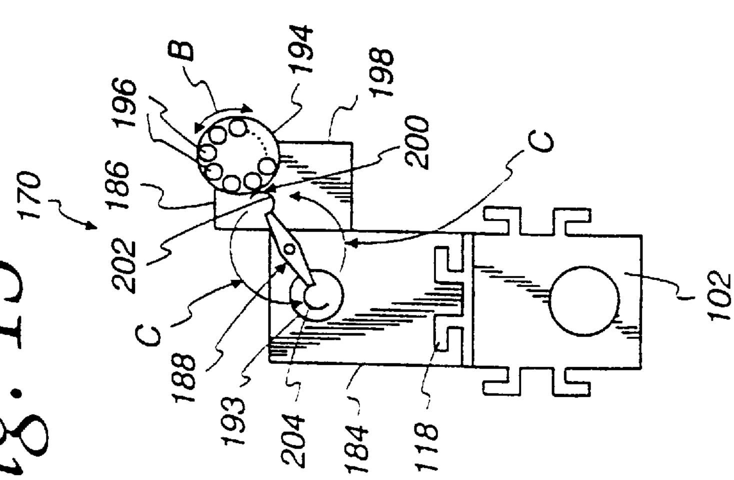

Fig. 15

AUTOMATED MACHINE TOOL INCLUDING A PLURALITY OF PROCESSING UNITS AND A SHARED TOOL STOCKER

FIELD OF THE INVENTION

This invention relates to machine tools and, more particularly, to automated machine tools.

BACKGROUND OF THE INVENTION

Automated transfer machines for performing a plurality of processing functions on a workpiece are well known. Typically, such machines include a plurality of self-contained processing units or machine tools organized in a fixed array on a shop floor. It is common for a self-contained processing unit to include a dedicated cutting tool storage device for storing a plurality of cutting tools and a cutting tool transfer device for transferring cutting tools in and out of the storage device for use in the processing unit. Workpiece transfer devices shuttle workpieces in a predetermined sequence from processing unit to processing unit so that each processing unit performs its processing function on the workpieces, thereby resulting in a finished workpiece. The control of the workpiece transfer units and the processing units is integrated.

While such transfer machines have proven successful in providing a relatively high workpiece production rate, they tend to require a relatively large amount of floor space because each processing unit has a dedicated base and a dedicated location on the shop floor.

Additionally, the workpiece transfer devices can become quite complex and expensive depending upon the overall size of the transfer machine and the size and shape of the workpiece.

Further, each processing unit may include a dedicated cutting tool storage device, thereby taking up an even greater amount of floor space and shop volume. Typically, when the transfer machine must be retooled, the processing units must be shut down and the cutting tools for each of the processing units must be transported to each of the dedicated processing units and loaded into each of the dedicated cutting tool storage devices.

SUMMARY OF THE INVENTION

In accordance with the present invention, a system for machining workpieces is provided and includes a first workpiece processing unit, a second workpiece processing unit, a shared storing device for storing a plurality of cutting tools to be used in the first and second processing units, and a first transfer device for selectively transferring cutting tools between the storing device and each of the first and second processing units.

In one form of the invention, the shared storing device includes a matrix of storage positions, each storage position being adapted to store a cutting tool. The first transfer device includes a robot arm adapted to selectively transfer cutting tools to and from each of the storage positions.

In one form of the invention, the first transfer device includes a second transfer device for transferring cutting tools to and from the first and second processing units, and a third transfer device for transferring cutting tools between the storing device and second transfer device.

In one form, the machining system further includes a frame. The second transfer device includes a carriage mounted on the frame for movement between a first location on the frame to effect transfer of cutting tools to and from the

first processing unit and a second location on the frame to effect transfer of cutting tools to and from the second processing unit. The first location is spaced from the second location.

In one form of the invention, the first and second locations are spaced circumferentially about an axis, the first and second processing units are mounted on the frame for rotation about the axis between the first and second locations, and the carriage includes a ring-shaped carrier mounted on the front for rotation about an axis.

In one form of the invention, the first workpiece processing unit includes a tool spindle, a dedicated storing device for storing a plurality of cutting tools to be used in the first processing unit, and a dedicated transfer device for transferring cutting tools between the tool spindle and the second storing device.

In one form of the invention, the dedicated storing device includes a matrix of storage positions and structure for indexing the matrix relative to a tool transfer location on the first workpiece processing unit. Each of the storage positions in the matrix is adapted to store a cutting tool. The dedicated transfer device includes a first tool carrier for carrying a tool between the tool spindle and the matrix, a second tool carrier for carrying a tool between the tool spindle and the matrix, and a drive for sequentially indexing the first and second tool carriers relative to the tool spindle and the tool transfer location.

In accordance with one aspect of the invention, a system for machine workpieces is provided and includes a frame, a first tool spindle mounted on the frame, a first storing device for storing a plurality of cutting tools to be used in the first tool spindle, a second storing device for storing a plurality of cutting tools to be used in the first tool spindle, a first transfer device for transferring cutting tools between the second storing structure and the first storage device, and a second transfer device for transferring cutting tools between the first tool spindle and the second storing structure.

In one form, the system further includes a second tool spindle mounted on the frame, a third storing device for storing a plurality of cutting tools to be used in the second tool spindle, and a third transfer device for transferring cutting tools between the second tool spindle and the third storing device. The first storing device includes structure for storing a plurality of cutting tools to be used in the second tool spindle. The first transfer device includes structure for transferring cutting tools between the third storing device and the first storing device.

In accordance with one aspect of the invention, a method of tooling an automated machining system is provided. The method includes the steps of providing a first processing unit, providing a second processing unit, providing a shared storing device for storing a plurality of tools to be used from the first and second processing units, providing a first transfer device for transferring tools to and from the first and second processing units, providing a second transfer device for transferring tools between the storage device and the first transfer device, transferring a first tool from the shared storage device to the first transfer device using the second transfer device, transferring the first tool to one of the first and second processing units using the first transfer device, and transferring a second tool from the shared storage device using the second transfer device. The steps of transferring the first tool to one of the first and second processing units and transferring a second tool from the storage device are performed substantially simultaneously.

In one form, the step of transferring the first tool to one of the first and second processing units includes the step of

repositioning the first transfer device relative to one of the first and second processing units.

In accordance with one aspect of the present invention, a method of tooling an automated machining system is provided. The method includes the steps of providing a tool spindle, providing a first storage device for storing a plurality of tools to be used in the tool spindle, providing a first transfer device for transferring tools between the tool spindle and the first storage device, providing a second tool storage device for storing a plurality of tools to be used in the tool spindle, providing a second transfer device for transferring tools between the second storage device and the first storage device, transferring a first cutting tool between the tool spindle and the first storage device using the first transfer device, and transferring a second cutting tool between the second storage device and the first storage device using the second transfer device. The transferring steps are performed substantially simultaneously.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagrammatic elevation view shown partially in section of a machining system embodying the present invention;

FIG. **2** is a diagrammatic plan view of the machining system shown in FIG. **1**;

FIG. **3** is a diagrammatic plan view showing a base, a rotatable carrier, and a processing unit platform of the machining system shown in FIG. **1**;

FIG. **4** is a cross-sectional view of the base, the carrier, and the processing unit platform taken along line **4**—**4** in FIG. **3**;

FIG. **5** is an enlarged diagrammatic view of the area encircled by line **5**—**5** in FIG. **4**;

FIG. **6** is a diagrammatic plan view showing a carrier and drive assembly of the machining system tool shown in FIG. **1**;

FIG. **7** is an enlarged roll-out view of the area indicated by line **7**—**7** in FIG. **6**;

FIG. **8** is a side elevation view of a lathe processing unit;

FIG. **9** is a right side elevation view of the unit shown in FIG. **8**;

FIG. **10** is a schematic representation of a rotational indexing drive of the machining system shown in FIG. **1**;

FIG. **11** is a diagrammatic view of a self-contained procuring unit of the machine tool shown in FIG. **1**;

FIG. **12** is a diagrammatic plan view of another machining system embodying the present invention;

FIG. **13** is a diagrammatic elevation view shown partially in section of the machining system shown in FIG. **13**;

FIG. **14** is a side elevation view of a machining center for use in the machining system shown in FIG. **12**;

FIG. **15** is a sectional view taken along line **15**—**15** shown in FIG. **14**; and

FIG. **16** is a plan view of the unit shown in FIG. **14**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. **1** and **2** show a diagrammatic illustration of an automated machining system or machine tool **20** embodying the present invention. The machine tool **20** includes a frame **22** having a workpiece transfer station **23** at a fixed location on the frame **22**, a carrier **24** mounted on the frame for rotation about a vertical axis **26**, and four self-contained machine tools or processing units **28** that are fixed to the carrier **24** at 90° intervals about the axis **26**. The processing units **28** are mounted on the carrier **24** for rotation about the axis **26** so that each of the processing units **28** can be sequentially indexed to the workpiece transfer station **23** for transferring workpieces to and from each of the processing units **28**.

The machine tool **20** further includes a coolant unit **30** for supplying cooling and cutting fluid to the processing units **28**; a power supply unit **32** for supplying electric and hydraulic power to any of the components of the machine tool **20** that require electric or hydraulic power, including any of the processing units **28**; a chip conveyor unit **34** for removing chips and other machining debris from the machine tool **20**; a cylindrical splash guard **36** that surrounds the upper portions of the processing units **28** to form a cylindrical machining chamber; an annular-shaped carriage or carrier **38** that is mounted to the frame **22** for rotation about the axis **26**; a robotic workpiece/cutting tool transfer device **40** that is fixed to the carrier **38** for rotation therewith about the axis **26**; a cylindrical-shaped safety guard **41** mounted to the frame **22** surrounding the carrier **38** and the workpiece/cutting tool transfer device **40**; automated opening and closing doors **42** and **44** located at the workpiece transfer station **23** to allow access to the interiors of the splash guard **36** and the safety guard **41**, respectively; an integrated control unit **46** for controlling the components of the machine tool **20**, including the carrier **24**, the processing units **28**, the cooling unit **30**, the power supply **32**, the chip-conveyor unit **34**, the carrier **38**, the workpiece transfer device **40**, and the automatic doors **42**,**44**; and a multiple conduit line **48** for transferring cutting fluid, coolant, control signals, and electric and hydraulic power between the processing units **28** and the control unit **46**, the cooling unit **30** and the power supply **32**.

The cooling unit **30**, the power supply **32**, the chip conveyor unit **34**, the splash guard **36**, the transfer device **40**, the safety guard **41**, the automatic doors **42**,**44**, the conduit line **48**, and the integrated control unit **46** are either conventional or are constructed utilizing conventional components and, accordingly, need not be described in further detail for an understanding of the invention.

As best seen in FIGS. **3** and **4**, the frame **22** includes a bowl-shaped base **49** mounting the carrier **24**. The carrier **24** consists of a rigid, annular outer rim **50**; a vertically-extending center mast or post **52**; and four ribs **54** rigidly connecting the post **52** to the rim **50**. Together, the rim **50**, the post **52** and the ribs **54** define four open processing areas **56** having adequate clearance to mount the processing units **28** and to allow free movement of the various components of the processing units **28** and of any workpieces carried by the processing units **28**. The post **52** includes four longitudinally-extending mount surfaces **57**, each of which is adapted to mount one of the processing units **28**. The post **52** also includes a longitudinally-extending opening **58** to allow cutting fluid, coolant, control signals, and hydraulic and electric power to be transferred between the conduit line **46** and the processing units **28** mounted on the post **52**. Conventional, rotatable couplings are provided between the conduit line **56** and the post **52** for the transfer of each of the cutting fluid, the coolant, the control signals, the hydraulic power, and the electric power. Connections are provided between the processing units **28** and the post **52** for transferring cutting fluid, coolant, control signals, and electric and hydraulic power as required for the particular type of processing unit **28**. These connections may be provided at the interface between the surface **57** and the processing unit **28**.

As best seen in FIG. **5**, the carrier **24** is mounted for rotation on the base **49** by an axial, deep-groove ball bearing **70** having a lower annular race **72** fixed to the base **49**, an upper annular race **74** fixed to the rim **50**, and a plurality of balls **76** separating the races **72** and **74**, as is conventional. The bearing **70** employs conventional technology. Accordingly, a more detailed description of the bearing **70** is unnecessary for an understanding of the invention. Further, it will be appreciated that any conventional bearing construction capable of carrying the described axial loads could be employed in the invention to rotatably mount the carrier **24** to the base **49**.

As best seen in FIG. **6**, a rotational drive assembly, shown generally at **80**, is provided for rotationally-driving the carrier **24** and the processing units **28** mounted thereon about the axis **26** and for sequentially indexing the processing units **28** to the workpiece transfer station **23**. The drive assembly **80** includes an endless, toothed drive belt **82**, a drive sprocket **84** for driving the belt **82**, a servo motor **86** for driving the drive sprocket **84** and the belt **82**, and a driven sprocket **88** mounted on the outer circumference of the rim **50** and drivably engaged with the belt **82**. As best seen in FIG. **7**, the driven sprocket **88** is formed from a toothed belt **89**, similar to the belt **82**, that has been wrapped around the outer circumference of the rim **50** and attached thereto by a suitable adhesive, thereby saving the cost of forming sprocket teeth on the outer circumference of the rim **50**. The timing between the carrier **24** and the motor **86** is maintained by the meshed teeth **90** of the belt **82** and the sprockets **84**,**88**. As shown schematically in FIG. **10**, a conventional position sensor **91** is provided between the carrier **24** and the base **49** to provide a signal to the control unit **46** indicative of the rotational position of the carrier **24** relative to the base **49** and the workpiece transfer station **23**. The control unit **46** utilizes the signal to control the motor **86** so that the processing units **28** are accurately indexed relative to the workpiece transfer station **23**.

It should be appreciated that the details of the drive assembly **80** are shown for illustrative purposes only and that any form of conventional rotational drive and positional control system may be used to rotate and index the carrier **24** and the processing units **28**. Thus, for example, the drive motor **86** could be operably engaged with the carrier **24** by a gear transmission that drives either a ring gear mounted on the rim **50** or a spur gear rotationally fixed to the post **52**.

As best seen in FIGS. **8** and **9**, the self-contained processing units **28** are illustrated in the form of numerically-controlled lathes **100**. However, it should be appreciated that the self-contained processing units **28** may take the form of any conventional machine tool having structure **28**A for holding the workpiece for processing and structure **28**B for performing a process on a workpiece, as shown in FIG. **11**. Such conventional machine tools include, but are not limited to, an injection molding machine, an EDM machine, an ECM machine, an EBM machine, a LBM machine, a CMM machine, a robot welding machine, a wire-cutting machine, and a laser-cutting machine. The structure **28**A for holding the workpiece may include, for example, a headstock assembly, a tailstock assembly, a table slide assembly or, in the case of an injection molding machine, a die set. The structure **28**B for performing a process on a workpiece may include, for example, a cutting tool holder, a cutting tool spindle, a turret slide assembly, a die injection mechanism, a welding mechanism, an electrical machining mechanism, or a laser.

Accordingly, within this application, "self-contained processing unit" generally is intended to mean a machine tool that has all the components required to hold a workpiece and to perform the processing function of the processing unit on the workpiece. Thus, for example, in FIGS. **1** and **2**, the lathes **100** are self-contained processing units **28** because each lathe **100** has a headstock **104** for holding a workpiece and at least one of the turret slide assemblies **108**, for performing lathe processing on the workpiece.

It should also be appreciated that a different type of processing unit **28** may be mounted on each of the mount surfaces **57** of the post **52**. Thus, a lathe **100** could be mounted on one of the surfaces **57**, a robot welding machine could be mounted on another of the surfaces **57**, an injection molding machine could be mounted on yet another of the surfaces **57**, and a laser-cutting machine could be mounted on the last surface **57**. It should also be appreciated that the various types of processing units **28** can be of a conventional construction modified to mate with the mount surfaces **57** and to operate freely within the processing areas **56**.

Each lathe **100** is constructed of a number of standardized components including a base or platform **102**, a main spindle or head stock assembly **104**, a secondary spindle or tailstock assembly **106**, two turret slide assemblies **108**, and a spindle drive motor **110**. The headstock assembly **104**, the tailstock assembly **106**, the two turret slide assemblies **108**, and the spindle drive motor **110** are all controlled in a conventional manner by the control unit **48**.

The platform **102** is a one-piece structure that includes a mount surface **112** adapted to mate with any of the mount surfaces **57** of the post **52**, a pair of longitudinally-extending side rails **114**,**116** that extend over the length of the platform **102**, a longitudinally-extending top rail **118** that extends partially over the length of the platform **102**, and a relief surface **120** that is parallel to the surface **112** and extends partially over the length of the platform **102**. The platform **102** further includes a hole **121** that extends longitudinally through the platform **102**. The hole **121** serves as a mount for the motor **110** and also aids in radiating heat generated by the components of the lathe.

Each of the turret slide assemblies **108** includes a conventional tool turret and drive assembly **130**, a conventional cross slide assembly **132** carrying the assembly **130** for translations along an axis X and a longitudinal slide assembly **134** carrying both of the assemblies **132** and **130** for translation along an axis Z. One of the turret slide assemblies **108** is mounted to the rail **114** by its longitudinal slide assembly **134** and the other turret slide assembly **108** is mounted to the other side rail **116** by its longitudinal slide assembly **134**.

The head stock **104** is mounted to the surface **120** and is driven through belts **136** by the drive motor **110**, which is mounted in the hole **121**. The tailstock assembly **106** includes a longitudinal slide assembly **138**. The slide assembly **138** is mounted to the top rail **118** for translating the tailstock assembly **106** along the Z axis.

It should be appreciated that the components **102**, **104**, **106**, **108** and **110** are standardized for the lathes **100** and may be interchanged therebetween. It will also be appreciated that each lathe **100** may be customized by mounting only selected components to the platform **102**.

As best seen in FIG. **5**, the annular carrier **38** is mounted to the base **49** for rotation about the axis **26** by a plurality of cantilevered rollers **150** that are spaced around the outer circumference for the base **49**. Each of the rollers **150** is rotatably mounted by a cantilevered shaft **151** to a bracket **152** which, in turn, is fixed to the base **49**.

The carrier **38** is rotatably driven and indexed by a drive, shown schematically at **153** in FIG. **1**, that is essentially

identical to the drive assembly **80** for the carrier **24**. Accordingly, a detailed description of the drive for the carrier **38** is not required and it should be appreciated that, similar to the carrier **24**, any conventional rotational drive and positional control system may be employed to drive and index the carrier **38** about the axis **26**.

Vibrational dampers, in the form of strips **160** of industrial Velcro® brand fasteners or other suitable hook and loop fasteners, are provided between certain strategic joints of the machine tool to isolate each of the various components of the machine tool **20** from the vibrations created by the other components of the machine tool **20**. Specifically, the Velcro® fastener strips **160** are provided at the joints between the mount surfaces **57** of the post **52** and the mount surfaces **112** of the platforms **102**, the rim **50** and the upper bearing race **74**, the base **49** and the lower bearing race **72**, and the base **49** and each of the brackets **152**. The strips **160** are attached to their associated components using a suitable adhesive and the joints are clamped together using suitable fasteners. As best seen in FIG. **7**, the strips **160** are also provided between the belt **89** and the rim **50** and are held in compression by a circumferential tension force in the belt **89** created by an interference fit between the belt **89** and the outer circumference of the rim **50**. In addition to damping vibrations, the Velcro® fastener strips **160** assist in reinforcing the joints between the components.

It should be appreciated that the strips **160** can be eliminated from any of the joints if it is determined that the structurally-transmitted vibrations across the joint are not a concern.

The machine tool **20** is capable of a variety of modes of operation. For example, in one mode, the machine tool is configured as shown in FIGS. **1** and **2**, with each of the processing units **28** being a lathe **100** with a single turret slide assembly **108**, a headstock assembly **104**, and a tailstock assembly **106** mounted on a platform **102**. Each of the turret slide assemblies **108** carries a complement of cutting tools capable of performing all of the required lathe operations on a workpiece of a given configuration. Four workpieces are sequentially loaded into the head stocks **104** of each of the lathes **100** as each of the lathes **100** is indexed to the workpiece transfer station **23** by rotation of the post **52** by the drive assembly **80**. The processing of each workpiece is begun immediately after it is loaded into the headstock **104** and, in this manner, all of the required lathe operations for four workpieces of a given configuration may be machined substantially simultaneously by the machine tool **20**. After each lathe **100** finishes processing its workpiece, the lathe **100** is indexed to the workpiece transfer station **23** and the processed workpiece is removed from the head stock **104** and an unprocessed workpiece is loaded. In this manner, the machine tool **20** can continuously process a plurality of workpieces.

In another mode, the machine tool **20** is configured as set forth above with the exception that each of the slide assemblies **108** carries a complement of tools for performing a set of processing functions different from the other slide assemblies **108**. In this mode, a first workpiece is loaded into the first lathe **100** after the first lathe **100** has been indexed to the work station **23**. The first lathe **100** then performs a first series of processing functions on the first workpiece. Next, the first workpiece is removed from the first lathe **100** and a second workpiece is loaded into the first lathe **100**. The second lathe **100** is then indexed to the work transfer station **23** and the first workpiece is loaded into the second lathe **100**, which then performs the second series of processing functions on the first workpiece substantially simultaneously

with the first lathe **100** performing the first series of processing functions on the second workpiece. After the first lathe **100** finishes the first series of processing functions on the second workpiece, the first lathe **100** is indexed back to the work transfer station **23** and the second workpiece is removed from the first processing unit and a third workpiece is loaded into the first lathe **100**. The second lathe **100** is then indexed back to the workpiece transfer station **23** and the first workpiece is removed and replaced with the second workpiece. The third lathe **100** is then indexed to the workpiece transfer station and the first workpiece is loaded therein and the third lathe **100** performs a third series of processing functions on the first workpiece substantially simultaneously with the second lathe **100** performing the second series of processing functions on the second workpiece and the first lathe **100** performing the first series of processing functions on the third workpiece. After the first lathe **100** finishes the first series of processing functions on the third workpiece, the lathe **100** is indexed to the workpiece transfer station **23** and the third workpiece is removed therefrom and replaced with a fourth workpiece. The second lathe **100** is then indexed to the workpiece transfer station **23** and the second workpiece is removed therefrom and replaced with the third workpiece. The third lathe **100** is then indexed to the workpiece transfer station and the first workpiece is removed therefrom and replaced with the second workpiece. The fourth lathe **100** is then indexed to the workpiece transfer station and the first workpiece is loaded into the fourth lathe **100**. The fourth lathe **100** then performs the fourth series of processing functions on the first workpiece substantially simultaneously with the third lathe **100** performing the third series of processing functions on the second workpiece, the second lathe **100** performing the second series of processing functions on the third workpiece, and the first lathe **100** performing the first series of processing functions on the fourth workpiece. After the first lathe **100** finishes the first series of processing functions on the fourth workpiece, the first lathe **100** is indexed to the workpiece transfer station **23** and the fourth workpiece is removed therefrom and a fifth workpiece is loaded into the lathe **100**. Next, the second lathe **100** is indexed to the workpiece transfer station **23** and the third workpiece is removed therefrom and replaced by the fourth workpiece. The third lathe **100** is then indexed to the workpiece transfer station **23** and the second workpiece is removed therefrom and replaced by the third workpiece. The fourth lathe is then indexed to the workpiece transfer station **23** and the first workpiece is removed therefrom and replaced by the second workpiece. The first workpiece is now finished and removed from the machine tool **20**, while the fourth lathe performs the fourth series of process functions on the second workpiece, the third lathe **100** performs the third series of process functions on the third workpiece, the second lathe **100** performs the second series of processing functions on the fourth workpiece, and the first lathe **100** performs the first series of processing functions on the fifth workpiece. In this manner, the machine tool **20** can continuously manufacture a plurality of workpieces requiring first, second, third and fourth series of processing functions. It should be appreciated that in this mode each of the lathes **100** may begin its series of processing functions on a workpiece as soon as the workpiece is loaded into the lathe **100**.

It should be appreciated that the workpieces can be transferred to and from the processing units either manually or by using the workpiece/cutting tool transfer device **40**.

As seen in FIG. **2**, if increased flexibility for the machine tool **20** is desired, additional workpiece transfer stations **23**

can be added to allow for the simultaneous transfer of workpieces to and from a plurality of the processing units **28**. Flexibility can be further increased by adding additional workpiece transfer devices **40** onto the carrier **38**.

FIGS. **12** and **13** show the machine tool **20** in yet another configuration, with each of the processing units **28** being a machining center **170**, rather than a lathe **100**. In this configuration, the machine tool **20** also includes a shared cutting tool storage device or stocker **172** for storing a plurality of cutting tools to be used in the processing units **28**. The shared tool stocker **172** is mounted to the frame **22** and includes a matrix **174** of tool storage positions **176**, as best seen in FIG. **12**. Each storage position **176** is adapted to store a cutting tool. The machine tool **20** also includes a robotic arm, cutting tool transfer device **178** mounted for linear movement along a rail **180**, as best seen in FIG. **12**, fixed to the tool stocker **172**. Additionally, as best seen in FIG. **12**, the machine tool **20** includes four transfer stations **23**,**23'**,**23"**, **23'"**, each having automatic doors **42**,**44**.

It should be understood that the tool stocker **172** and the transfer device **178** may be of any suitable and known construction. In one preferred embodiment, the matrix **174** would have approximately **200** storage positions **176**.

As best seen in FIGS. **14–16**, each of the machining centers **170** is constructed of a number of standardized components that are attached to one of the platforms **102**. The standardized components include a workpiece table assembly **182** that is fixed to the top rail **118**, a cutting tool drive spindle assembly **184** that is mounted to the top rail **118** for translation along the top rail **118**, a dedicated cutting tool storing device **186** for storing a plurality of cutting tools to be used in the machining center **170**, and a dedicated cutting tool transfer device **188** for transferring cutting tools between the tool storing device **186** and the spindle assembly **184**.

The table assembly **182** includes X and Y slide assemblies **190** and **192** for translating a workpiece along respective X and Y axes relative to a cutting tool driven by the spindle assembly **184**.

The spindle assembly **184** includes a cutting tool spindle **193** for holding a cutting tool as it is rotatably driven by the spindle assembly **184**. The spindle **193** is mounted in the assembly **184** for translation along a Z axis.

The tool storing device **186** includes a tool storage matrix **194** having a plurality of cutting tool storage positions **196**. The tool storing device **186** further includes a drive **198** for indexing the matrix **194** relative to a tool transfer location **200**, as indicated by the arrow B.

The transfer device **188** includes a first tool carrier **202** for carrying a cutting tool between the spindle **193** and the matrix **194**, and a second tool carrier **204** for carrying a tool between the tool spindle **193** and the matrix **194**. As best seen in FIG. **16**, a drive **206** is provided in the spindle assembly **184** for indexing the first and second tool carriers **202**,**204** relative to the tool spindle **185** and the tool transfer location **200**, as indicated by the arrows C.

The workpiece table assembly **182**, the cutting tool drive spindle assembly **184**, the storing device **186**, and the transfer device **188** are either conventional or are constructed utilizing conventional components and, accordingly, need not be described in further detail for an understanding of the invention.

The configuration of the machine tool **20** shown in FIGS. **12**,**13** operates in the same manner as previously described in connection with the configuration shown in FIGS. **1**,**2**. Additionally, the configuration of the machine tool **20** shown

in FIGS. **12**,**13** allows for the machine tool **20** to be retooled while maintaining continuous operation of the machine tool **20**. More specifically, in operation, an inventory of cutting tools is stored in the shared tool stocker **172** for shared use in the processing units **28**. Additionally, a plurality of cutting tools are stored in the dedicated tool storing devices **194** on the processing units **28**. When it is desired to replace one of the cutting tools in a tool storing device **194** on one of the processing units **28**, the processing unit **28** and the workpiece/cutting tool transfer device **40** are indexed to one of the transfer stations **23**,**23'**,**23"**,**23'"**. The automatic door **42** is opened and the workpiece/cutting tool transfer device reaches into the processing area **56** and removes a cutting tool from the matrix **194**. If the workpiece/cutting tool transfer device **40** is not at the transfer position **23"**, the transfer device **40** is indexed to the transfer position **23'** and the automatic door **44** is open. The transfer devices **40** and **178** then cooperate to transfer the cutting tool from the transfer device **40** to the transfer device **178**. The transfer device **178** then places the cutting tool in an empty storage position **176** of the matrix **174**, translating along the rail **180** if required. While the transfer device **178** is placing the cutting tool into a storage position **176**, the transfer device **40** may be removing another cutting tool from another one of the processing units **28** according to the method as previously described.

When it is desired to transfer a cutting tool from the tool stocker **172** to one of the processing units **28**, the transfer device **178** is translated along the rail **180** to adjacent one of the storage positions **176** and removes a cutting tool from the storage position **176**. The transfer device **178** then translates along the rail **180** to adjacent the transfer position **23**. The automatic door **44** is opened and the transfer devices **178** and **40** cooperate to transfer the cutting tool from the transfer device **178** to the transfer device **40**. The processing unit **28** and the transfer device **40** are then indexed to one of the transfer stations **23**,**23'**,**23"**,**23'"**, and the automatic door **42** is opened. The transfer device **40** then reaches into the processing area **56** and places the cutting tool into the matrix **194** of the processing unit. While the transfer device **40** is indexing to the appropriate transfer station **23**,**23'**,**23"**,**23'"**, and transferring the cutting tool to the appropriate matrix **194**, the transfer device **178** may remove another cutting tool from a storage position **176** in the matrix **174**.

It should be appreciated that if a processing unit **28** is already at the desired transfer station **23**,**23'**,**23"**,**22'"**, only the transfer device **40** will be indexed. Similarly, if the transfer device **40** is already at the desired transfer station **23**,**23'**,**23"**, **23'"**, only the processing unit **28** must be indexed. If both the transfer device **40** and the processing unit **28** are at the desired transfer station **23**,**23'**,**23"**,**23'"**, no indexing is required.

While the transfer devices **40**, **178** are transferring a cutting tool between a processing unit **28** and the shared tool stocker **172**, the dedicated transfer device **188** may be transferring cutting tools between the matrix **194** and the tool spindle **193**. In this operation, one of the tool carriers **202**, **204** removes a cutting tool from the matrix **194** while the other tool carrier **202**, **204** removes a cutting tool from the tool spindle **193**. The transfer device **188** is then indexed 180° as indicated by the arrows C so that the cutting tool from the matrix **194** is aligned with the tool spindle **193** and the cutting tool from the tool spindle **193** is aligned with the transfer position **200**. The tool carriers **202**,**204** then place their respective cutting tools into the matrix **194** and the tool spindle **184**.

It should be appreciated that the invention contemplates that more or less than four processing units **28** may be

configured on the machine tool **20**. Thus, for example, the carrier **24** may be configured with only two processing areas **56** and two mount surfaces **57** on the post **52**. By way of further example, a carrier **24** may be configured with eight processing areas **56** and eight mount surfaces **57** on the post **52** to accommodate eight processing units **28**.

It will be appreciated that by mounting a plurality of self-contained processing units on a single frame so that the processing units can be sequentially indexed to a workpiece transfer station for workpiece loading and unloading, the machine tool **20** can provide the benefits of a conventional transfer machine without requiring the floor space of a conventional transfer machine, the additional cost of dedicated bases for each processing unit, or a complex workpiece transfer device.

It should also be appreciated that by providing a shared tool stocker **172** that stores tools for all of the processing units **28** of the machine tool **20**, the size of the dedicated tool storing devices **186** associated with each processing unit **28** may be made smaller than the dedicated tool stockers used on conventional transfer machines.

It should also be appreciated that an operator may replace cutting tools stored in the tool stocker **172** while the machine tool **20** is operating, thereby allowing for continuous operation of the machine tool **20**.

What is claimed is:

1. A system for machining workpieces, said machining system comprising:

a first workpiece processing unit;

a second workpiece processing unit;

means for storing a plurality of cutting tools to be used in said first and second processing units;

first transfer means for selectively transferring cutting tools between the storing means and each of the first and second processing units, said first transfer means comprising

a) second transfer means for transferring cutting tools to and from said first and second processing units, said second transfer means comprising a carriage mounted on the frame for movement between a first location on said frame to effect transfer of cutting tools to and from said first processing unit and a second location on said frame to effect transfer of cutting tools to and from said second processing unit, said first location being spaced from said second location, said carriage comprising a ring-shaped carrier mounted on said frame for rotation about an axis; and

b) third transfer means for transferring cutting tools between said storing means and said second transfer means.

2. A system for machining workpieces, said system comprising:

a frame;

a first tool spindle mounted on the frame;

first means for storing a plurality of cutting tools to be used in said first tool spindle;

second means for storing a plurality of cutting tools to be used in said first tool spindle;

first transfer means for transferring cutting tools between said second storing means and said first storing means; and

second transfer means for transferring cutting tools between said first tool spindle and said second storing means;

a second tool spindle mounted on the frame;

third means for storing a plurality of cutting tools to be used in said second tool spindle;

third transfer means for transferring cutting tools between said second tool spindle and said third storing means; and wherein

said first storing means comprises means for storing a plurality of cutting tools to be used in said second tool spindle, and

said first transfer means comprises means for transferring cutting tools between said third storing means and said first storing means.

3. A method of tooling an automated machining system, said method comprising the steps of:

a) providing a first processing unit;

b) providing a second processing unit;

c) providing a storing device for storing a plurality of tools to be used in the first and second processing units;

d) providing a first transfer device for transferring tools to and from the first and second processing units;

e) providing a second transfer device for transferring tools between the storage device and the first transfer device;

f) transferring a first tool from the storage device to the first transfer device using the second transfer device;

g) transferring the first tool to one of the first and second processing units using the first transfer device; and

h) transferring a second tool from the storage device using the second transfer device.

4. The method of claim **3** wherein steps g and h are performed substantially simultaneously.

5. The method of claim **3** wherein step g includes repositioning the first transfer device relative to the one of the first and second processing units.

6. A system for machining workpieces, said machining system comprising:

a frame;

a first self-contained processing unit mounted on the frame for movement between a first location on said frame and a second location on said frame spaced from said first location;

a second self-contained processing unit mounted on said frame for movement between said first and second locations;

a shared tool stocker comprising a matrix of tool storage positions to store a plurality of cutting tools for use in said first and second processing units; and

a cutting tool transfer device mounted on the frame to transfer cutting tools between the shared tool stocker and said first and second processing units at least at one of said first and second locations on said frame.

7. The machining system of claim **6** wherein said first and second locations are spaced circumferentially about an axis, and said first and second processing units are mounted on said frame for rotation about the axis between said first and second locations.

8. The machining system of claim **6** further comprising a machining debris shield that is mounted on said frame and surrounds said first and second processing units, a first automated opening and closing door in said shield at said first location to allow transfer of cutting tools through the shield, and a second automated opening and closing door at said second location to allow transfer of cutting tools through the shield.

9. The machining system of claim **6** wherein said cutting tool transfer device is mounted on said shared tool stocker.

10. The machining system of claim **6** wherein said first workpiece processing unit comprises a dedicated tool stocker to store a plurality of cutting tools to be used in said first workpiece processing unit.

11. The machining system of claim **10** wherein said first processing unit further comprises a tool spindle, and a dedicated transfer device to transfer cutting tools between the tool spindle and the dedicated tool stocker.

12. The machining system of claim **6** wherein said cutting tool transfer device comprises a carriage mounted on the frame for movement between said first and second locations.

13. The machining system of claim **12** wherein said cutting tool transfer device further comprises a cutting tool transfer device mounted on the frame to transfer cutting tools between the shared tool stocker and the carriage.

14. The machining system of claim **12** wherein said carriage comprises a ring-shaped carrier mounted on the frame for rotation about an axis.

15. A system for machining workpieces, said machining system comprising:

a first self-contained processing unit including a first dedicated tool stocker;

a second self-contained processing unit including a second dedicated tool stocker;

a shared cutting tool stocker to store a plurality of cutting tools for use in the first and second processing units;

a first cutting tool transfer device to remove cutting tools from the shared tool stocker; and

a second cutting tool transfer device mounted on a frame for movement between a first position wherein cutting tools from the shared tool stocker are transferred to the second transfer device by the first transfer device, and a second position wherein the second transfer device transfers cutting tools to and from the first and second dedicated tool stockers.

16. A method of tooling an automated machining system, said method comprising the steps of:

removing a first tool from a shared tool stocker using a first transfer device;

transferring the first tool from the first transfer device to a second transfer device;

transferring the first tool to a first dedicated tool stocker on a first self-contained processing unit using the second transfer device;

removing a second tool from the shared tool stocker using the first transfer device;

transferring the second tool from the first transfer device to the second transfer device; and

transferring the second tool from the second transfer device to a second dedicated storage tool stocker on a second self-contained processing unit.

* * * * *

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United States Patent [19]

Miyano

[11] **Patent Number: 6,081,986**

[45] **Date of Patent: Jul. 4, 2000**

[54] **AUTOMATED MACHINE TOOL INCLUDING A PLURALITY OF PROCESSING UNITS**

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[22] Filed: **Dec. 5, 1996**

[51] **Int. Cl.**[7] **B23Q 7/14**; B23P 23/00

[52] **U.S. Cl.** .... **29/563**; 29/38 R; 29/38 A; 29/38 C; 29/564

[58] **Field of Search** .... 29/563, 564, 33 P, 29/38 P, 38 B, 38 C, 38 R, 33 J, 33 K; 409/251, 273; 82/124; 408/46

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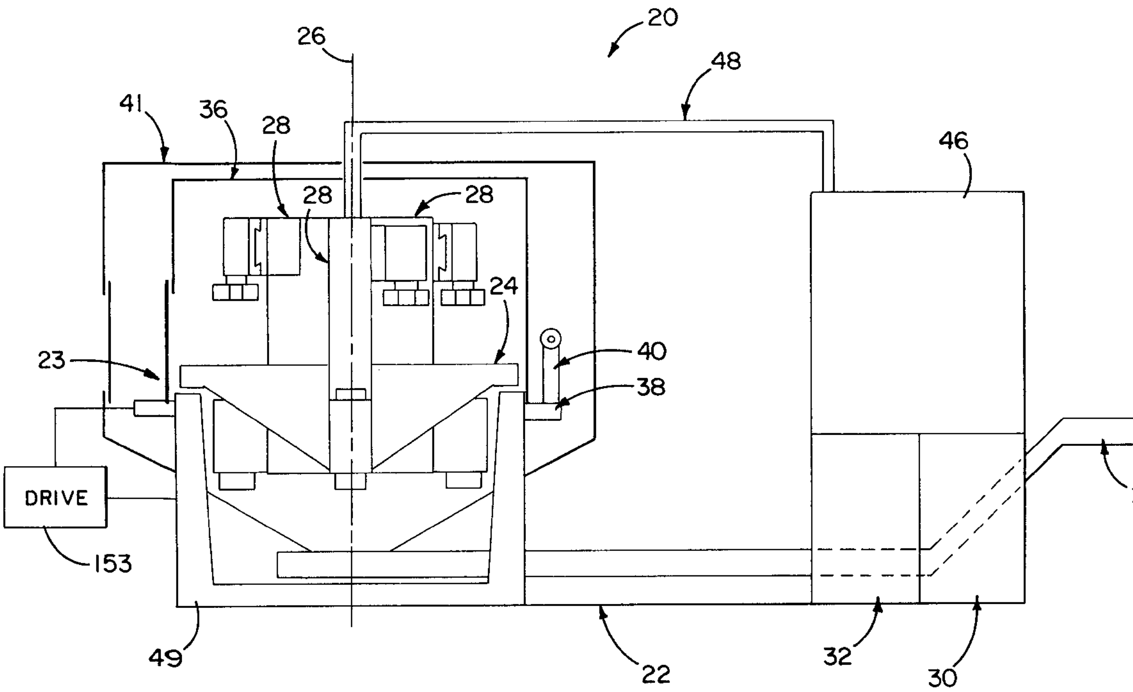
Primary Examiner—William Briggs
Attorney, Agent, or Firm—Wood, Phillips, VanSanten, Clark & Mortimer

[57] **ABSTRACT**

An automated machine tool is provided and includes a frame having a first workpiece transfer station at a first location on the frame; at least two self-contained processing units, each of the units including structure for holding the workpiece for processing and structure for performing a process on the workpiece; and structure for sequentially indexing the processing units to the first workpiece transfer station for transferring workpieces to and from each of the processing units.

5 Claims, 5 Drawing Sheets



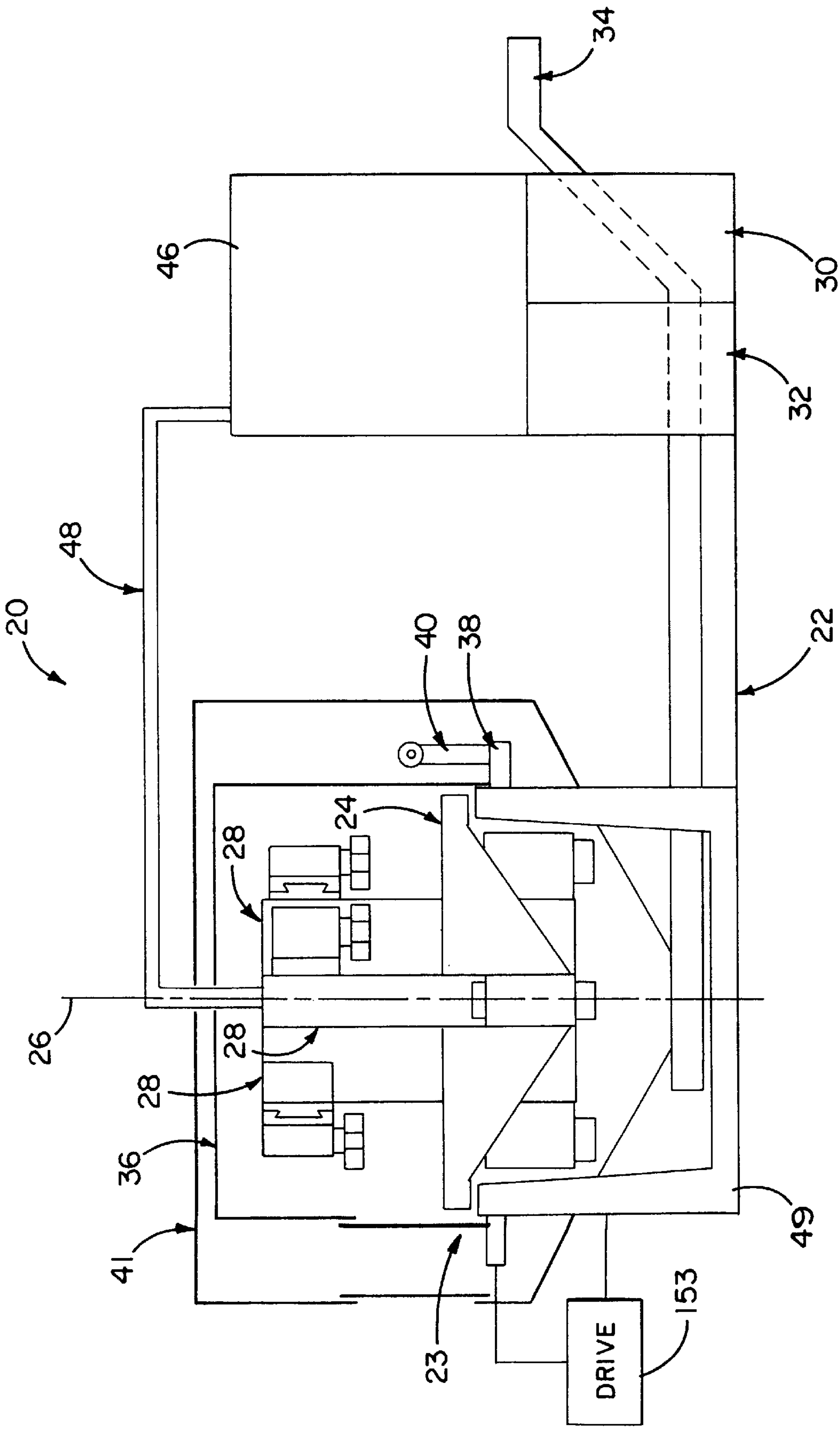


FIG. 1

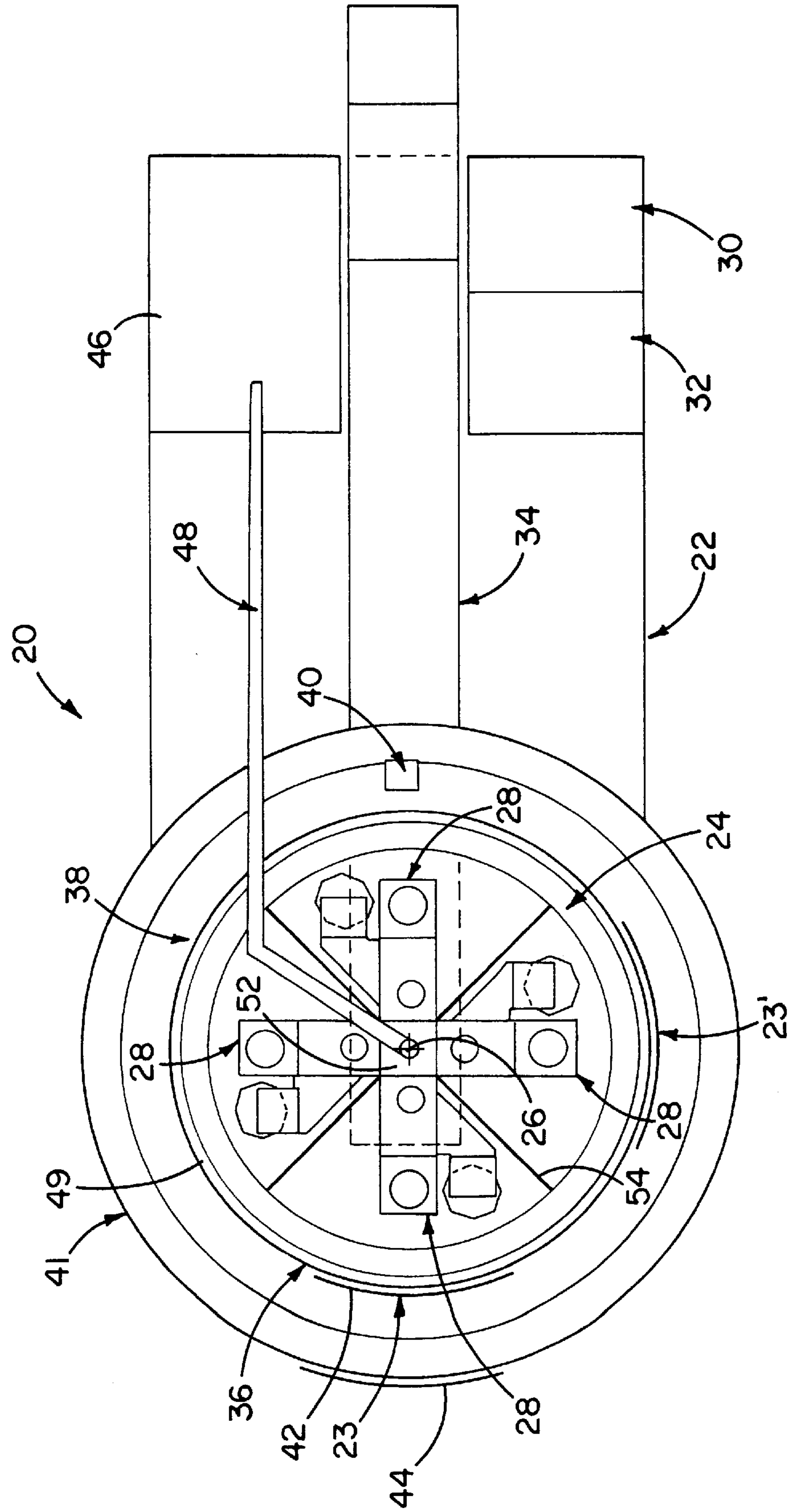


FIG. 2

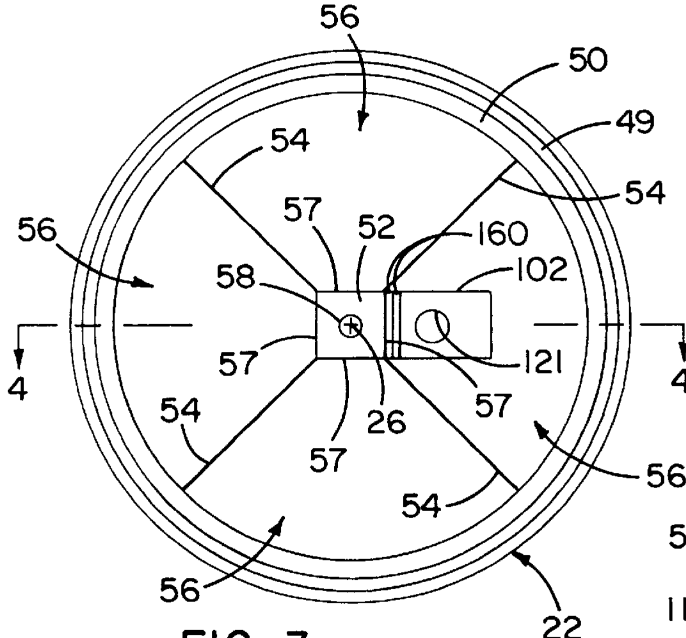


FIG. 3

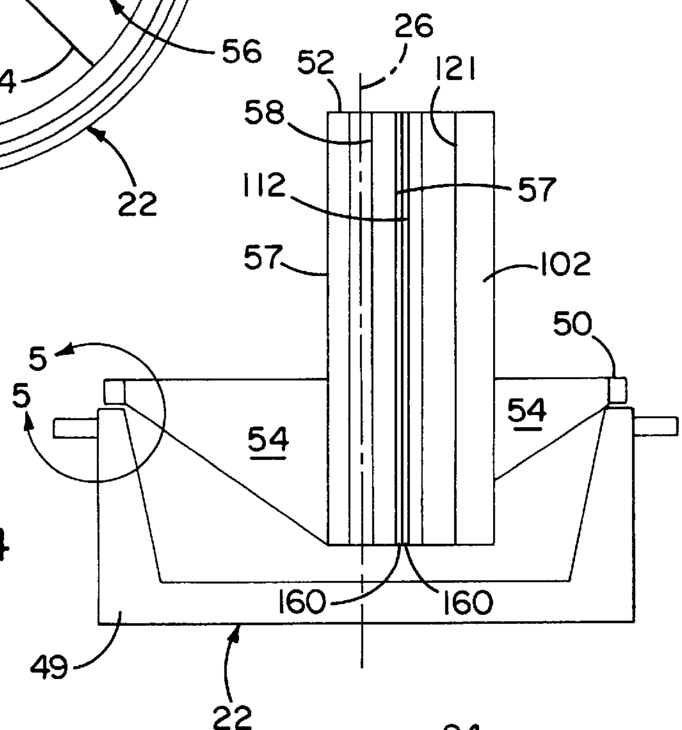


FIG. 4

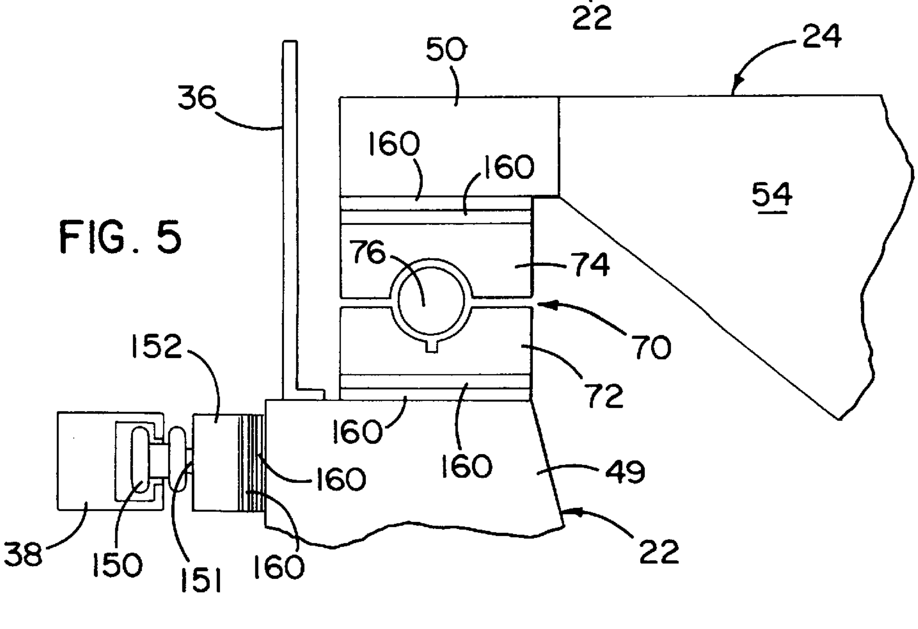


FIG. 5

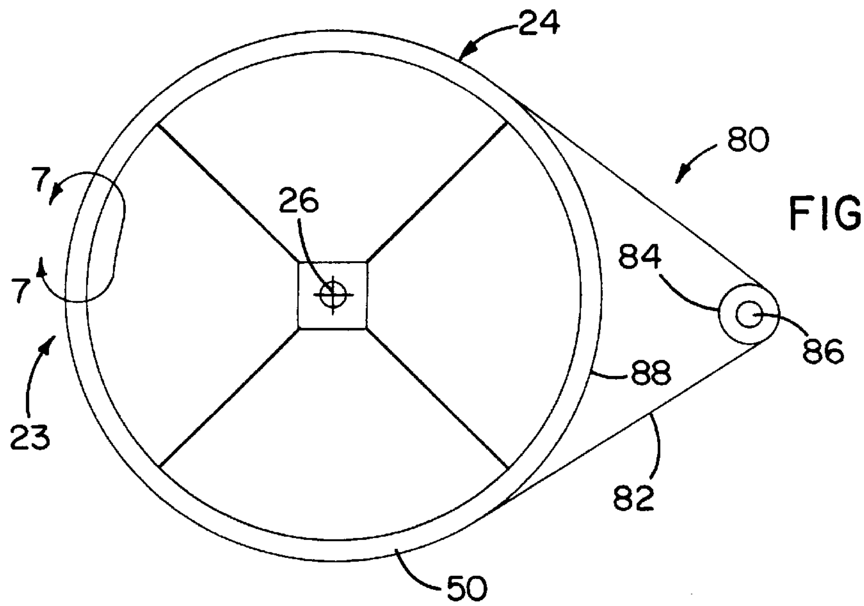


FIG. 6

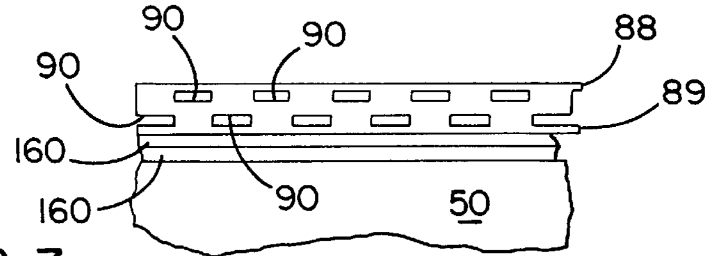
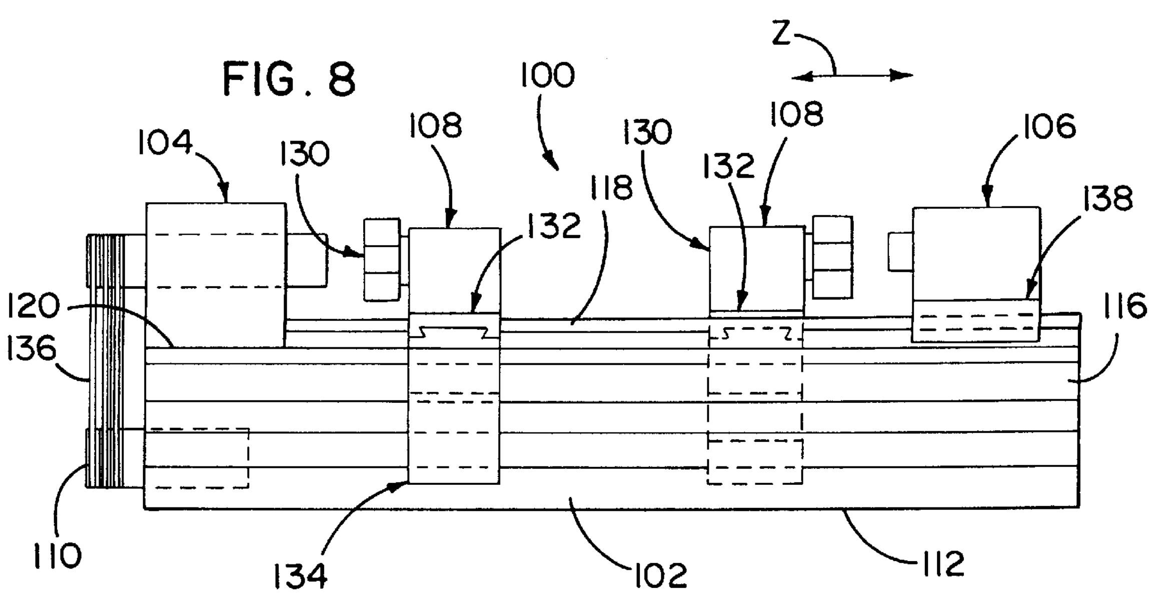


FIG. 7

FIG. 8



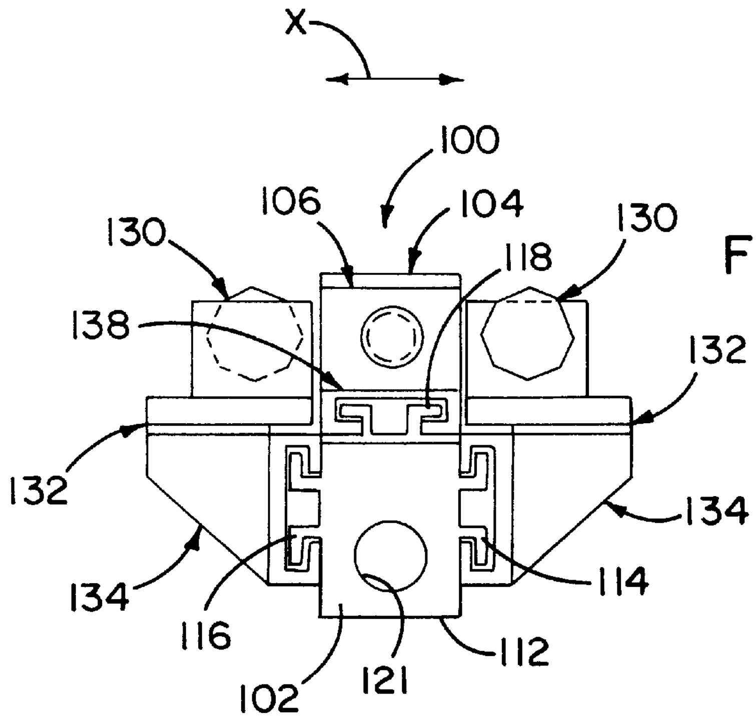


FIG. 9

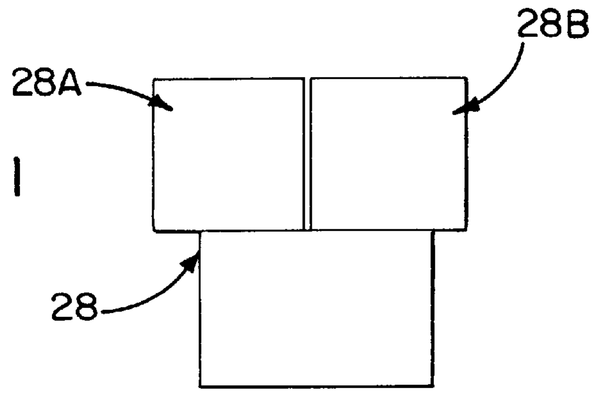


FIG. 11

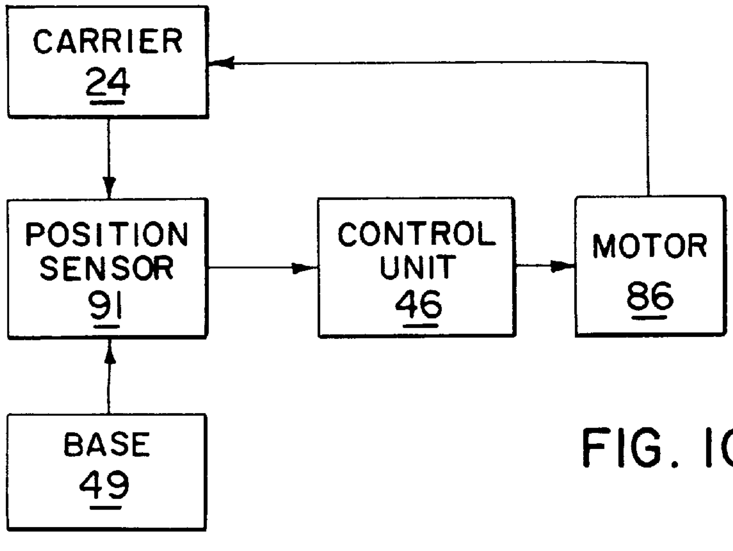


FIG. 10

AUTOMATED MACHINE TOOL INCLUDING A PLURALITY OF PROCESSING UNITS

FIELD OF THE INVENTION

This invention relates to machine tools and, more particularly, to automated machine tools.

BACKGROUND OF THE INVENTION

Automated transfer machines for performing a plurality of processing functions on a workpiece are well known. Typically, such machines include a plurality of self-contained processing units or machine tools organized in a fixed array on a shop floor. Workpiece transfer devices shuttle workpieces in a predetermined sequence from processing unit to processing unit so that each processing unit performs its processing function on the workpieces, thereby resulting in a finished workpiece. The control of the workpiece transfer units and the processing units is integrated.

While such transfer machines have proven successful in providing a relatively high workpiece production rate, they tend to require a relatively large amount of floor space because each processing unit has a dedicated base and a dedicated location on the shop floor. Additionally, the workpiece transfer devices can become quite complex and expensive depending upon the overall size of the transfer machine and the size and shape of the workpiece.

SUMMARY OF THE INVENTION

In accordance with the present invention, an automated machine tool is provided and includes a frame having a first workpiece transfer station at a first location on the frame; at least two self-contained processing units, each of the units including structure for holding the workpiece for processing and structure for performing a process on a workpiece; and structure for sequentially indexing the processing units to the first workpiece transfer station for transferring workpieces to and from each of the processing units.

In one form of the invention, the structure for performing the process includes at least one of a cutting tool holder, a cutting tool spindle, a turret slide assembly, die injection mechanism, a welding mechanism, an electrical machining mechanism, a wire-cutting assembly, and a laser machining mechanism.

In one form of the invention, the structure for holding a workpiece includes at least one of a head stock assembly, a die set, a tailstock assembly, and a table slide assembly.

In one form of the invention, the structure for sequentially indexing the processing units includes a support mounted on the frame for rotation about an axis. The support carries the processing units for rotation about the axis.

In one form of the invention, the structure for sequentially indexing the processing units further includes a first toothed belt driven by a motor and a second toothed belt fixed to the support and drivably engaged with the first toothed belt.

In one form of the invention, the machine tool further includes structure for releasably mounting at least one of the processing units on the support. The structure includes a first strip of hook and loop material on the support, and a second strip of hook and loop material on at least one of the processing units. The first and second strips are sandwiched between the support and the processing unit.

In one form of the invention, the first and second strips are made from Velcro® material.

In one form of the invention, a second workpiece transfer station is provided on the frame at a second location spaced from the first location. A workpiece transfer device is provided for transferring workpieces to and from the processing units at the transfer stations. Structure is provided for moving the workpiece transfer unit between the first and second workpiece transfer stations.

In accordance with one aspect of the present invention, a method of processing a workpiece is provided and includes the steps of providing a workpiece; providing first and second self-contained processing units, with the first processing unit performing a first processing function and the second processing unit performing a second processing function; performing a first processing function on the workpiece with the first processing unit; and, after performing the first processing function with the first processing unit, repositioning the second processing unit relative to the workpiece and performing a second processing function on the workpiece using the second processing unit.

In one form of the invention, the first and second processing units each have a workpiece holder and the method further includes the steps of holding the workpiece with the workpiece holder in the first processing as the first processing function is performed, releasing the workpiece form the workpiece holder in the first processing unit after completion of the first processing function, and holding the workpiece with the workpiece holder in the second processing unit while the second processing function is performed.

In one form of the invention, the step of repositioning the second processing unit relative to the workpiece includes rotating the second processing unit about an axis.

In one form of the invention, the first process function includes at least one of machining the workpiece with a cutting tool, injection-molding the workpiece, welding the workpiece, electrical machining the workpiece, and laser machining the workpiece.

In accordance with one aspect of the present invention, a method of processing a plurality of workpieces is provided. The method includes the steps of providing first and second workpieces; providing first and second self-contained processing units, each of the processing units comprising means for holding the workpiece for processing and means for processing the workpiece; providing a transfer location for transferring workpieces to and from the first and second processing units; moving the first processing unit to the transfer location; transferring the first workpiece into the holding means of the first processing unit; initiating processing of the first workpiece by the first processing unit; moving the first processing unit from the transfer location; moving the second processing unit to the transfer location; transferring the second workpiece into the holding means of the second processing unit; and initiating processing of the second workpiece with the second processing unit.

In one form of the invention, the step of moving the first processing unit to the transfer location includes rotating the first processing unit about an axis.

In one form of the invention, the method further includes the steps of moving the second processing unit from the transfer location, returning the first processing unit to the transfer location, transferring the first workpiece from the first processing unit, moving the first processing unit from the transfer location, returning the second processing unit to the transfer location, and transferring the second workpiece from the second processing unit.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagrammatic elevation view shown partially in section of a machine tool embodying the present invention;

FIG. **2** is a diagrammatic plan view of the machine tool shown in FIG. **1**;

FIG. **3** is a diagrammatic plan view showing a base, a rotatable carrier, and a processing unit platform of the machine tool shown in FIG. **1**;

FIG. **4** is a cross-sectional view of the base, the carrier, and the processing unit platform taken along line **4**—**4** in FIG. **3**;

FIG. **5** is an enlarged diagrammatic view of the area encircled by line **5**—**5** in FIG. **4**;

FIG. **6** is a diagrammatic plan view showing a carrier and drive assembly of the machine tool shown in FIG. **1**;

FIG. **7** is an enlarged roll-out view of the area indicated by line **7**—**7** in FIG. **6**;

FIG. **8** is a side elevation view of a lathe processing unit embodying the present invention; and

FIG. **9** is a right side elevation view of the unit shown in FIG. **8**;

FIG. **10** is a schematic representation of a rotational indexing drive of the machine tool shown in FIG. **1**; and

FIG. **11** is a diagrammatic view of a self-contained procuring unit of the machine tool shown in FIG. **1**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. **1** and **2** show a diagrammatic illustration of an automated machine tool **20** embodying the present invention. The machine tool **20** includes a frame **22** having a workpiece transfer station **23** at a fixed location on the frame **22**, a carrier **24** mounted on the frame for rotation about a vertical axis **26**, and four self-contained machine tools or processing units **28** that are fixed to the carrier **24** at 90° intervals about the axis **26**. The processing units **28** are mounted on the carrier **24** for rotation about the axis **26** so that each of the processing units **28** can be sequentially indexed to the workpiece transfer station **23** for transferring workpieces to and from each of the processing units **28**.

The machine tool **20** further includes a coolant unit **30** for supplying cooling and cutting fluid to the processing units **28**; a power supply unit **32** for supplying electric and hydraulic power to any of the components of the machine tool **20** that require electric or hydraulic power, including any of the processing units **28**; a chip conveyor unit **34** for removing chips and other machining debris from the machine tool **20**; a cylindrical splash guard **36** that surrounds the upper portions of the processing units **28** to form a cylindrical machining chamber; an annular-shaped carrier **38** that is mounted to the frame **22** for rotation about the axis **26**; a robotic workpiece transfer device **40** that is fixed to the carrier **38** for rotation therewith about the axis **26**; a cylindrical-shaped safety guard **41** mounted to the frame **22** surrounding the carrier **38** and the workpiece transfer device **40**; automatic doors **42** and **44** located at the workpiece transfer station **23** to allow access to the interiors of the splash guard **36** and the safety guard **41**, respectively; an integrated control unit **46** for controlling the components of the machine tool **20**, including the carrier **24**, the processing units **28**, the cooling unit **30**, the power supply **32**, the chip-conveyor unit **34**, the carrier **38**, the workpiece transfer device **40**, and the automatic doors **42**,**44**; and a multiple conduit line **48** for transferring cutting fluid, coolant, control signals, and electric and hydraulic power between the processing units **28** and the control unit **46**, the cooling unit **30** and the power supply **32**.

The cooling unit **30**, the power supply **32**, the chip conveyor unit **34**, the splash guard **36**, the safety guard **41**, the automatic doors **42**,**44**, the conduit line **48**, and the integrated control unit **46** are either conventional or are constructed utilizing conventional components and, accordingly, need not be described in further detail for an understanding of the invention.

As best seen in FIGS. **3** and **4**, the frame **22** includes a bowl-shaped base **49** mounting the carrier **24**. The carrier **24** consists of a rigid, annular outer rim **50**; a vertically-extending center mast or post **52**; and four ribs **54** rigidly connecting the post **52** to the rim **50**. Together, the rim **50**, the post **52** and the ribs **54** define four open processing areas **56** having adequate clearance to mount the processing units **28** and to allow free movement of the various components of the processing units **28** and of any workpieces carried by the processing units **28**. The post **52** includes four longitudinally-extending mount surfaces **57**, each of which is adapted to mount one of the processing units **28**. The post **52** also includes a longitudinally-extending opening **58** to allow cutting fluid, coolant, control signals, and hydraulic and electric power to be transferred between the conduit line **46** and the processing units **28** mounted on the post **52**. It should be appreciated that conventional, rotatable couplings must be provided between the conduit line **48** and the post **52** for the transfer of each of the cutting fluid, the coolant, the control signals, the hydraulic power, and the electric power. It should further be appreciated that connections must be provided between the processing units **28** and the post **52** for transferring cutting fluid, coolant, control signals, and electric and hydraulic power as required for the particular type of processing unit **28**. These connections may be provided at the interface between the surface **57** and the processing unit **28**.

As best seen in FIG. **5**, the carrier **24** is mounted for rotation on the base **49** by an axial, deep-groove ball bearing **70** having a lower annular race **72** fixed to the base **49**, an upper annular race **74** fixed to the rim **50**, and a plurality of balls **76** separating the races **72** and **74**, as is conventional. The bearing **70** employs conventional technology. Accordingly, a more detailed description of the bearing **70** is unnecessary for an understanding of the invention. Further, it will be appreciated that any conventional bearing construction capable of carrying the described axial loads could be employed in the invention to rotatably mount the carrier **24** to the base **49**.

As best seen in FIG. **6**, a rotational drive assembly, shown generally at **80**, is provided for rotationally-driving the carrier **24** and the processing units mounted thereon about the axis **26** and for sequentially indexing the processing units **28** to the workpiece transfer station **23**. The drive assembly **80** includes an endless, toothed drive belt **82**, a drive sprocket **84** for driving the belt **82**, a servo motor **86** for driving the drive sprocket **84** and the belt **82**, and a driven sprocket **88** mounted on the outer circumference of the rim **50** and drivably engaged with the belt **82**. As best seen in FIG. **7**, the driven sprocket **88** is formed from a toothed belt **89**, similar to the belt **82**, that has been wrapped around the outer circumference of the rim **50** and attached thereto by a suitable adhesive, thereby saving the cost of forming sprocket teeth on the outer circumference of the rim **50**. The timing between the carrier **24** and the motor **86** is maintained by the meshed teeth **90** of the belt **82** and the sprockets **84**,**88**. As shown schematically in FIG. **10**, a conventional position sensor **91** is provided between the carrier **24** and the base **49** to provide a signal to the control unit **46** indicative of the rotational position of the carrier **24** relative to the base **49** and the workpiece transfer station **23**. The control unit **46** utilizes the signal to control the motor **86** so that the

processing units **28** are accurately indexed relative to the workpiece transfer station **23**.

It should be appreciated that the details of the drive assembly **80** are shown for illustrative purposes only and that any form of conventional rotational drive and positional control system may be used to rotate and index the carrier **24** and the processing units **28**. Thus, for example, the drive motor **86** could be operably engaged with the carrier **24** by a gear transmission that drives either a ring gear mounted on the rim **50** or a spur gear rotationally fixed to the post **52**.

As best seen in FIGS. **8** and **9**, the processing units **28** are illustrated in the form of numerically-controlled lathes **100**. However, it should be appreciated that the processing units **28** may take the form of any conventional machine tool having workpiece holder **28**A for holding the workpiece for processing and workpiece processor **28**B for performing a process on a workpiece, as shown in FIG. **11**. Such conventional machine tools include, but are not limited to, an injection molding machine, an EDM machine, an ECM machine, an EBM machine, a LBM machine, a CMM machine, a robot welding machine, a wire-cutting machine, and a laser-cutting machine. The workpiece holder **28**A for holding the workpiece may include, for example, a headstock assembly, a tailstock assembly, a table slide assembly or, in the case of an injection molding machine, a die set. The workpiece processor **28**B for performing a process on a workpiece may include, for example, a cutting tool holder, a cutting tool spindle, a turret slide assembly, a die injection mechanism, a welding mechanism, an electrical machining mechanism, or a laser.

It should also be appreciated that a different type of processing unit **28** may be mounted on each of the mount surfaces **57** of the post **52**. Thus, a lathe **100** could be mounted on one of the surfaces **57**, a robot welding machine could be mounted on another of the surfaces **57**, an injection molding machine could be mounted on yet another of the surfaces **57**, and a laser-cutting machine could be mounted on the last surface **57**. It should also be appreciated that the various types of processing units **28** can be of a conventional construction modified to mate with the mount surfaces **57** and to operate freely within the processing areas **56**.

Each lathe **100** is constructed of a number of standardized components including a base or platform **102**, a main spindle or head stock assembly **104**, a secondary spindle or tailstock assembly **106**, two turret slide assemblies **108**, and a spindle drive motor **110**. The headstock assembly **104**, the tailstock assembly **106**, the two turret slide assemblies **108**, and the spindle drive motor **110** are all controlled in a conventional manner by the control unit **48**.

The platform **102** is a one-piece structure that includes a mount surface **112** adapted to mate with any of the mount surfaces **57** of the post **52**, a pair of longitudinally-extending side rails **114**,**116** that extend over the length of the platform **102**, a longitudinally-extending top rail **118** that extends partially over the length of the platform **102**, and a relief surface **120** that is parallel to the surface **112** and extends partially over the length of the platform **102**. The platform **102** further includes a hole **121** that extends longitudinally through the platform **102**. The hole **121** serves as a mount for the motor **110** and also aids in radiating heat generated by the components of the lathe.

Each of the turret slide assemblies **108** includes a conventional tool turret and drive assembly **130**, a conventional cross slide assembly **132** carrying the assembly **130** for translations along an axis X and a longitudinal slide assembly **134** carrying both of the assemblies **132** and **130** for translation along an axis Z. One of the turret slide assemblies **108** is mounted to the rail **114** by its longitudinal slide assembly **134** and the other turret slide assembly **108** is mounted to the other side rail **116** by its longitudinal slide assembly **134**.

The head stock **104** is mounted to the surface **120** and is driven through belts **136** by the drive motor **110**, which is mounted in the hole **121**. The tailstock assembly **106** includes a longitudinal slide assembly **138**. The slide assembly **138** is mounted to the top rail **118** for translating the tailstock assembly **106** along the Z axis.

It should be appreciated that the components **102**, **104**, **106**, **108** and **110** are standardized for the lathes **100** and may be interchanged therebetween. It will also be appreciated that each lathe **100** may be customized by mounting only selected components to the platform **102**.

As best seen in FIG. **5**, the annular carrier **38** is mounted to the base **40** for rotation about the axis **26** by a plurality of cantilevered rollers **150** that are spaced around the outer circumference for the base **49**. Each of the rollers **150** is rotatably mounted by a cantilevered shaft **151** to a bracket **152** which, in turn, is fixed to the base **49**.

The carrier **38** is rotatably driven and indexed by a drive, shown schematically at **153** in FIG. **2**, that is essentially identical to the drive assembly **80** for the carrier **24**. Accordingly, a detailed description of the drive for the carrier **38** is not required and it should be appreciated that, similar to the carrier **24**, any conventional rotational drive and positional control system may be employed to drive and index the carrier **38** about the axis **26**.

Vibrational dampers, in the form of strips **160** of industrial Velcro® fasteners or other suitable hook and loop fasteners, are provided between certain strategic joints of the machine tool to isolate each of the various components of the machine tool **20** from the vibrations created by the other components of the machine tool **20**. Specifically, the Velcro® fastener strips **160** are provided at the joints between the mount surfaces **57** of the post **52** and the mount surfaces **112** of the platforms **102**, the rim **50** and the upper bearing race **74**, the base **49** and the lower bearing race **72**, and the base **49** and each of the brackets **152**. The strips **160** are attached to their associated components using a suitable adhesive and the joints are clamped together using suitable fasteners. As best seen in FIG. **7**, the strips **160** are also provided between the belt **89** and the rim **50** and are held in compression by a circumferential tension force in the belt **89** created by an interference fit between the belt **89** and the outer circumference of the rim **50**. In addition to damping vibrations, the Velcro® fastener strips **160** assist in reinforcing the joints between the components.

It should be appreciated that the strips **160** can be eliminated from any of the joints if it is determined that the structurally-transmitted vibrations across the joint are not a concern.

The machine tool **20** is capable of a variety of modes of operation. For example, in one mode, the machine tool is configured as shown in FIGS. **1** and **2**, with each of the processing units **28** being a lathe **100** with a single turret slide assembly **108**, a headstock assembly **104**, and a tailstock assembly **106** mounted on a platform **102**. Each of the turret slide assemblies **108** carries a complement of cutting tools capable of performing all of the required lathe operations on a workpiece of a given configuration. Four workpieces are sequentially loaded into the head stocks **104** of each of the lathes **100** as each of the lathes **100** is indexed to the workpiece transfer station **23** by rotation of the post

52 by the drive assembly 80. The processing of each workpiece is begun immediately after it is loaded into the headstock 104 and, in this manner, all of the required lathe operations for four workpieces of a given configuration may be machined substantially simultaneously by the machine tool 20. After each lathe 100 finishes processing its workpiece, the lathe 100 is indexed to the workpiece transfer station 23 and the processed workpiece is removed from the head stock 104 and an unprocessed workpiece is loaded. In this manner, the machine tool 20 can continuously process a plurality of workpieces.

In another mode, the machine tool 20 is configured as set forth above with the exception that each of the slide assemblies 108 carries a complement of tools for performing a set of processing functions different from the other slide assemblies 108. In this mode, a first workpiece is loaded into the first lathe 100 after the first lathe 100 has been indexed to the work station 23. The first lathe 100 then performs a first series of processing functions on the first workpiece. Next, the first workpiece is removed from the first lathe 100 and a second workpiece is loaded into the first lathe 100. The second lathe 100 is then indexed to the work transfer station 23 and the first workpiece is loaded into the second lathe 100, which then performs the second series of processing functions on the first workpiece substantially simultaneously with the first lathe 100 performing the first series of processing functions on the second workpiece. After the first lathe 100 finishes the first series of processing functions on the second workpiece, the first lathe 100 is indexed back to the work transfer station 23 and the second workpiece is removed from the first processing unit and a third workpiece is loaded into the first lathe 100. The second lathe 100 is then indexed back to the workpiece transfer station 23 and the first workpiece is removed and replaced with the second workpiece. The third lathe 100 is then indexed to the workpiece transfer station and the first workpiece is loaded therein and the third lathe 100 performs a third series of processing functions on the first workpiece substantially simultaneously with the second lathe 100 performing the second series of processing functions on the second workpiece and the first lathe 100 performing the first series of processing functions on the third workpiece. After the first lathe 100 finishes the first series of processing functions on the third workpiece, the lathe 100 is indexed to the workpiece transfer station 23 and the third workpiece is removed therefrom and replaced with a fourth workpiece. The second lathe 100 is then indexed to the workpiece transfer station 23 and the second workpiece is removed therefrom and replaced with the third workpiece. The third lathe 100 is then indexed to the workpiece transfer station and the first workpiece is removed therefrom and replaced with the second workpiece. The fourth lathe 100 is then indexed to the workpiece transfer station and the first workpiece is loaded into the fourth lathe 100. The fourth lathe 100 then performs the fourth series of processing functions on the first workpiece substantially simultaneously with the third lathe 100 performing the third series of processing functions on the second workpiece, the second lathe 100 performing the second series of processing functions on the third workpiece, and the first lathe 100 performing the first series of processing functions on the fourth workpiece. After the first lathe 100 finishes the first series of processing functions on the fourth workpiece, the first lathe 100 is indexed to the workpiece transfer station 23 and the fourth workpiece is removed therefrom and a fifth workpiece is loaded into the lathe 100. Next, the second lathe 100 is indexed to the workpiece transfer station 23 and the third workpiece is removed therefrom and replaced by the fourth workpiece. The third lathe 100 is then indexed to the workpiece transfer station 23 and the second workpiece is removed therefrom and replaced by the third workpiece. The fourth lathe is then indexed to the workpiece transfer station 23 and the first workpiece is removed therefrom and replaced by the second workpiece. The first workpiece is now finished and removed from the machine tool 20, while the fourth lathe performs the fourth series of process functions on the second workpiece, the third lathe 100 performs the third series of process functions on the third workpiece, the second lathe 100 performs the second series of processing functions on the fourth workpiece, and the first lathe 100 performs the first series of processing functions on the fifth workpiece. In this manner, the machine tool 20 can continuously manufacture a plurality of workpieces requiring first, second, third and fourth series of processing functions. It should be appreciated that in this mode each of the lathes 100 may begin its series of processing functions on a workpiece as soon as the workpiece is loaded into the lathe 100.

It should be appreciated that the workpieces can be transferred to and from the processing units either manually or by using the workpiece transfer device 40.

As seen in FIG. 2, if increased flexibility for the machine tool 20 is desired, additional workpiece transfer stations 23 can be added to allow for the simultaneous transfer of workpieces to and from a plurality of the processing units 28. Flexibility can be further increased by adding additional workpiece transfer devices 40 onto the carrier 38.

Within this application, "self-contained processing unit" generally is intended to mean a machine tool that has all the components required to hold a workpiece and to perform the processing function of the processing unit on the workpiece. Thus, for example, in FIGS. 1 and 2, the lathes 100 are self-contained processing units 28 because each lathe 100 has a headstock 104 for holding a workpiece and at least one of the turret slide assemblies 108, for performing lathe processing on the workpiece.

It should be appreciated that the invention contemplates that more or less than four processing units 28 may be configured on the machine tool 20. Thus, for example, the carrier 24 may be configured with only two processing areas 56 and two mount surfaces 57 on the post 52. By way of further example, a carrier 24 may be configured with eight processing areas 56 and eight mount surfaces 57 on the post 52 to accommodate eight processing units 28.

It will be appreciated that by mounting a plurality of self-contained processing units on a single frame so that the processing units can be sequentially indexed to a workpiece transfer station for workpiece loading and unloading, the machine tool 20 can provide the benefits of a conventional transfer machine without requiring the floor space of a conventional transfer machine, the additional cost of dedicated bases for each processing unit, or a complex workpiece transfer device.

What is claimed is:

1. An automated machine tool comprising:

a frame comprising a first workpiece transfer station at a first location on the frame and a second workpiece transfer station at a second location on the frame spaced from the first location;

at least two self-contained processing units mounted on the frame for movement between the first and second workpiece transfer stations, each of the processing units capable of holding and performing a process on a workpiece;

a workpiece transfer device mounted to the frame for movement between the first and second workpiece transfer stations to transfer workpieces to and from the processing units at the transfer stations; and

an annular carrier mounted to the frame for rotation about an axis, the workpiece transfer device being mounted on the carrier for rotation about the axis with the carrier between the first and second workpiece transfer stations.

2. An automated machine tool comprising:

a frame comprising a first workpiece transfer station at a first location on the frame and a second workpiece transfer station at a second location on the frame spaced from the first location;

at least two self-contained processing units mounted to the frame for movement between the first and second workpiece transfer stations for the transfer of workpieces to and from each of the processing units;

a workpiece transfer device mounted to the frame for movement between the first and second workpiece transfer stations to transfer workpieces to and from the processing units at the transfer stations;

a splash guard mounted to the frame between the processing units and the workpiece transfer device; and

a safety guard mounted to the frame such that the workpiece transfer device is positioned between the safety guard and the splash shield.

3. An automated machine tool comprising:

a frame comprising a first workpiece transfer station at a first location on the frame;

at least two self-contained processing units, each capable of holding and performing a process on a workpiece;

a support mounted on the frame for rotation about an axis, said support carrying said processing units;

a motor;

a first tooth belt driven by the motor; and

a second tooth belt affixed to the support and driveably engaged with the first tooth belt to rotate the support about the axis.

4. An automated machine tool comprising:

a frame comprising a first workpiece transfer station at a first location on the frame;

at least two self-contained processing units, each capable of holding and performing a process on a workpiece;

a support mounted on the frame for rotation about an axis, said support carrying said processing units, the support being movable around the axis to sequentially move the processing units to the first workpiece transfer station for the transfer of workpieces to and from each of the processing units; and

a first strip of hook and loop material on said support and a second strip of hook and loop material on at least one of said processing units, said first and second strips sandwiched between said support and said at least one of said processing units and releasably mounting the at least one processing unit on said support.

5. The machine tool of claim **4** wherein said first and second strips are made from Velcro® material.

* * * * *

US006401324B1

(12) **United States Patent**
Miyano

(10) **Patent No.: US 6,401,324 B1**
(45) **Date of Patent: Jun. 11, 2002**

(54) **MACHINE TOOL ASSEMBLY AND METHOD OF PERFORMING MACHINING OPERATIONS USING THE MACHINE TOOL ASSEMBLY**

(76) Inventor: **Toshiharu Tom Miyano**, 50 Dundee La., Barrington Hills, IL (US) 60010

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/633,519**

(22) Filed: **Aug. 7, 2000**

(51) **Int. Cl.**[7] **B23Q 1/25**; B23B 17/00; B23B 39/00; B23C 1/00

(52) **U.S. Cl.** .... **29/564**; 29/26 A; 29/27 R; 29/38 A; 29/38 B; 29/38 C; 82/124; 82/129; 408/234; 409/134; 409/137; 409/235; 451/453

(58) **Field of Search** .... 29/564, 563, 26 R, 29/27 R, 27 C, 38 R, 38 B, 38 A, 38 C, 560; 82/124, 129; 408/234, 67; 409/235, 136, 137, 134; 451/453, 340

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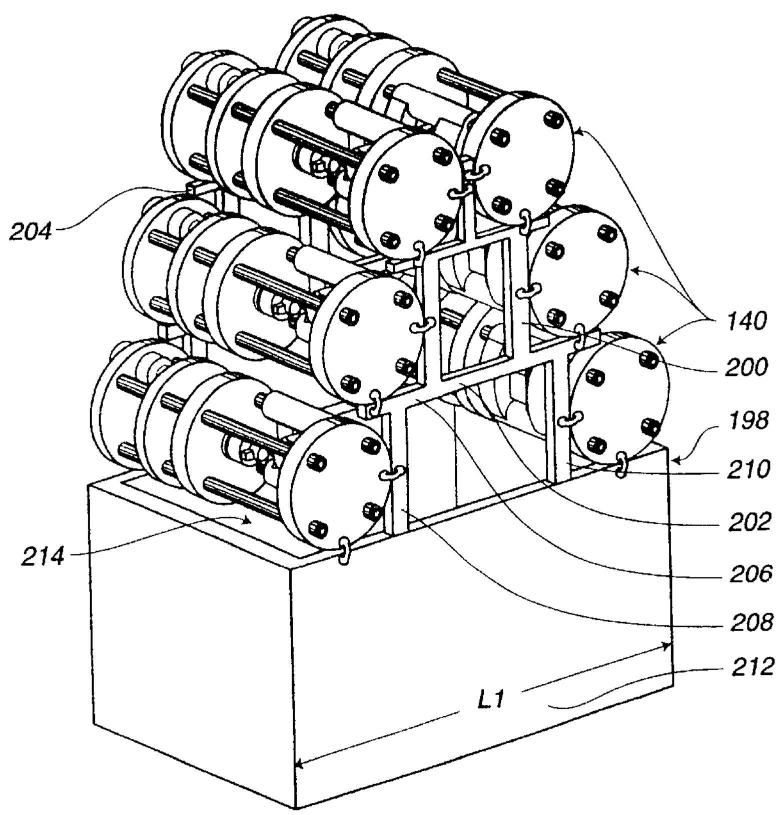
(74) *Attorney, Agent, or Firm*—Wood, Phillips, Katz, Clark & Mortimer

(57) **ABSTRACT**

The combination of at least a first base, a first machine tool assembly placed in an operative position on the at least first base, and a second machine tool assembly placed in an operative position on the at least first base above the first machine tool assembly.

16 Claims, 6 Drawing Sheets



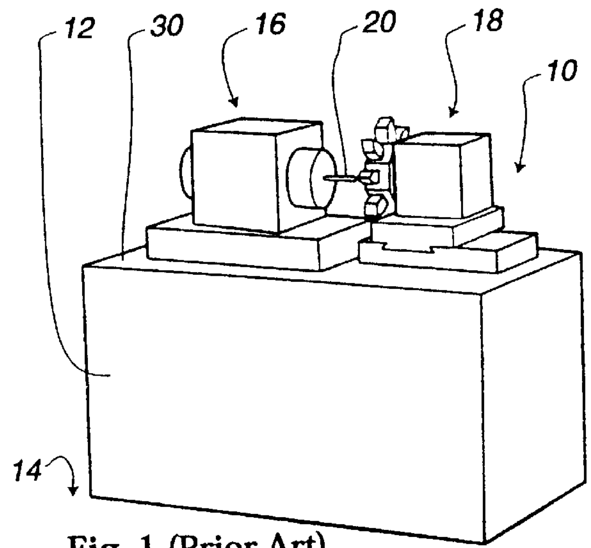


Fig. 1 (Prior Art)

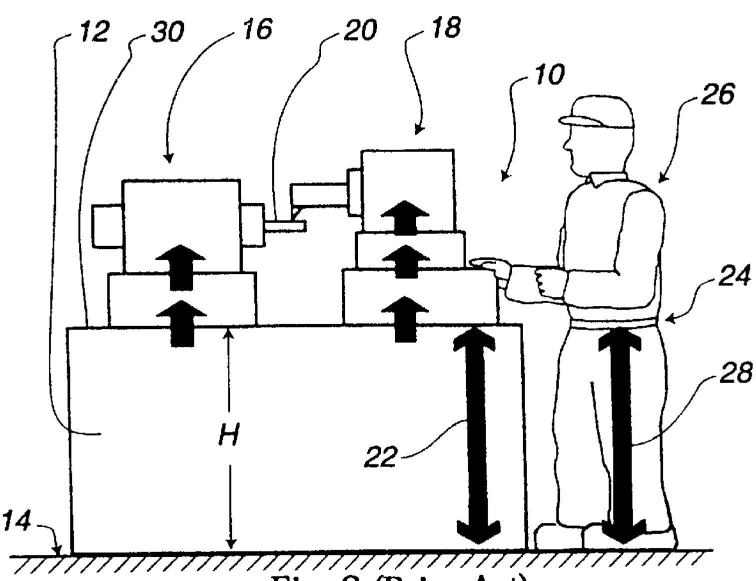


Fig. 2 (Prior Art)

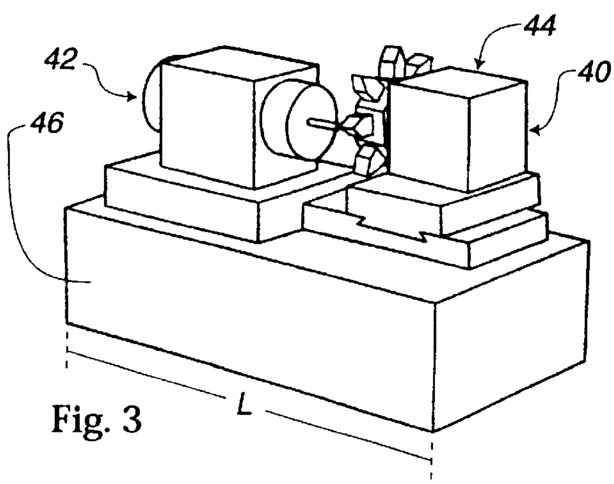


Fig. 3

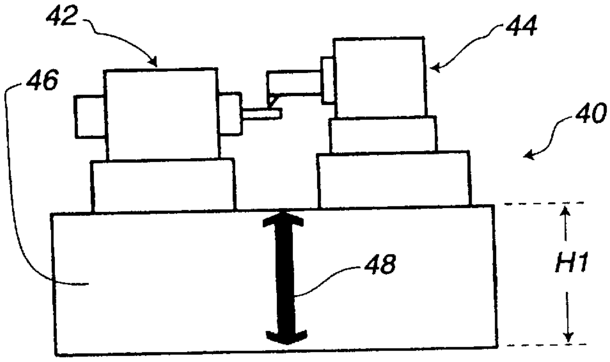


Fig. 4

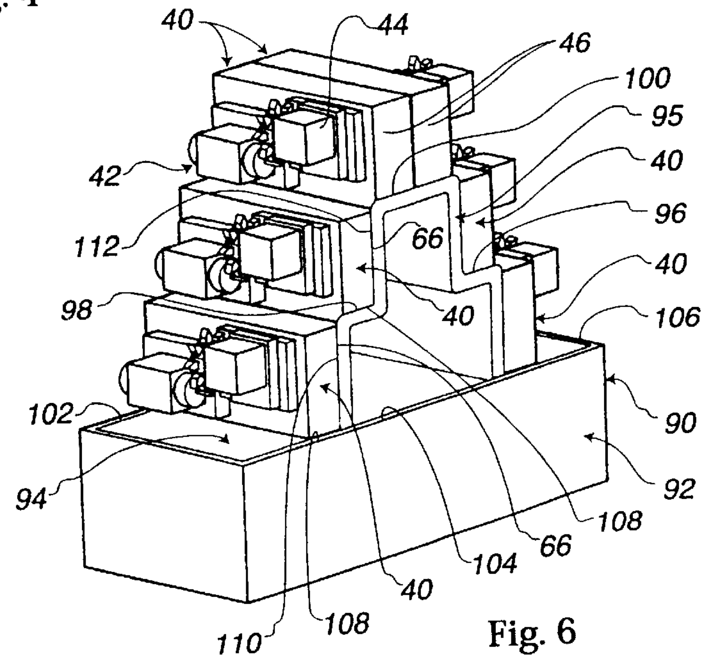


Fig. 6

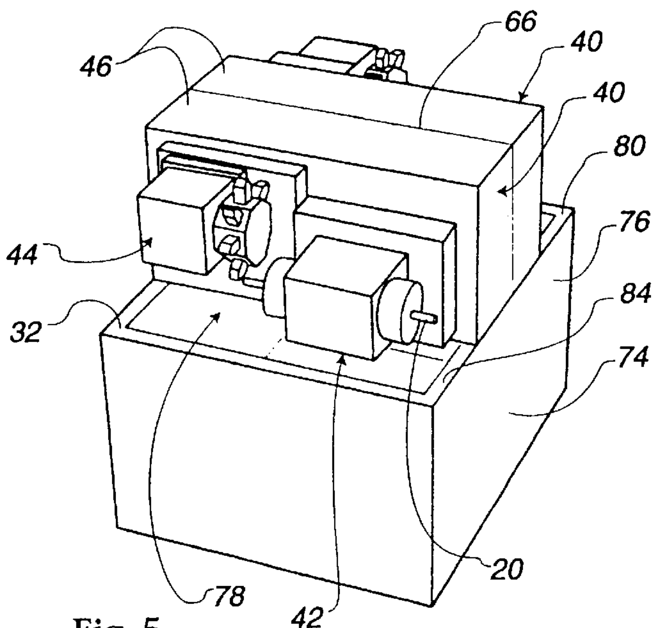


Fig. 5

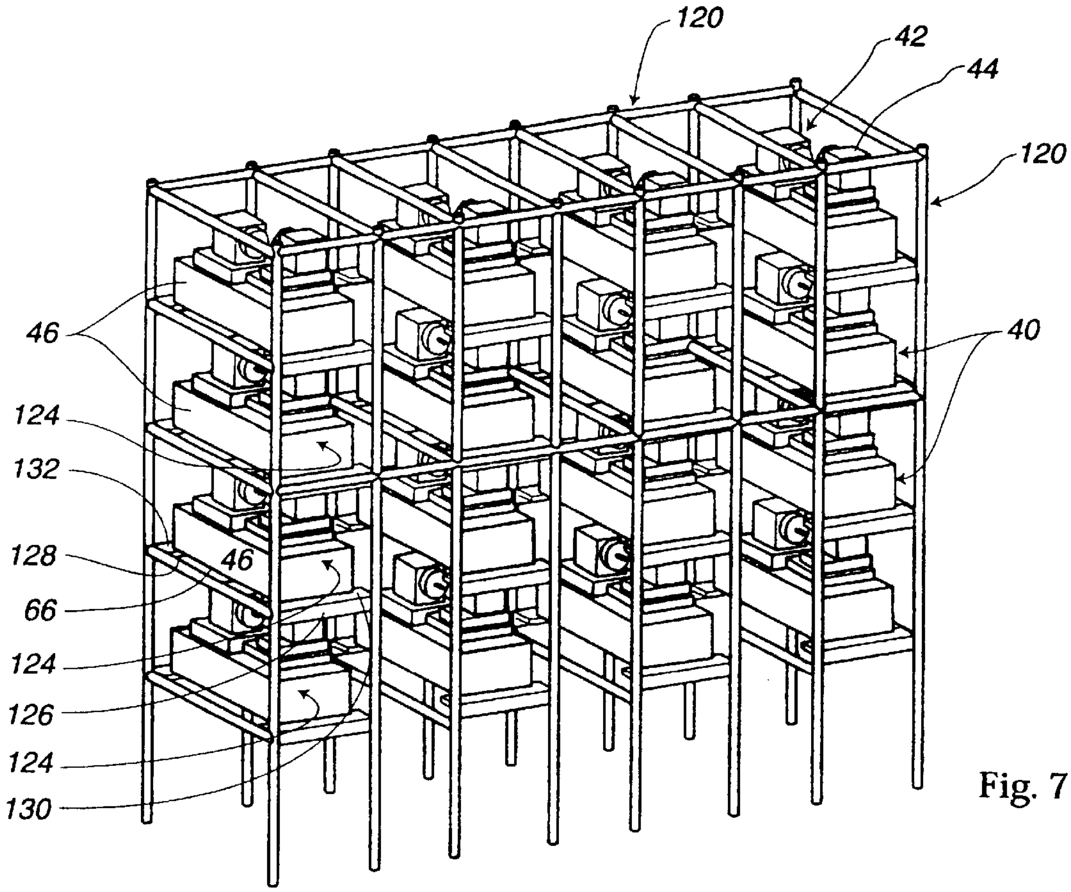

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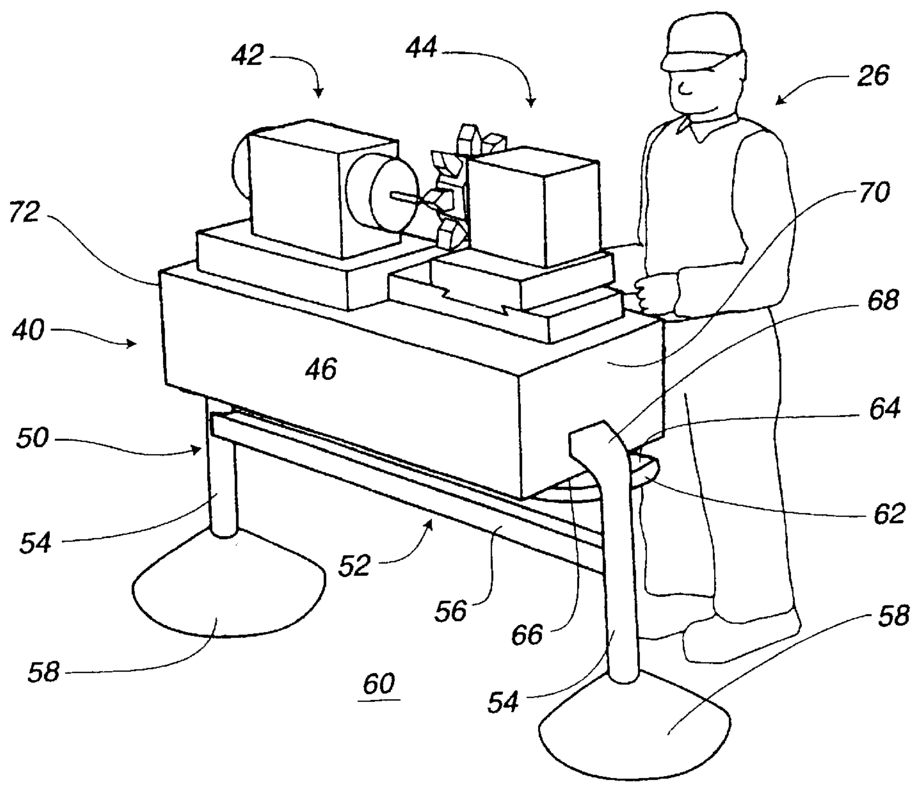
Fig. 7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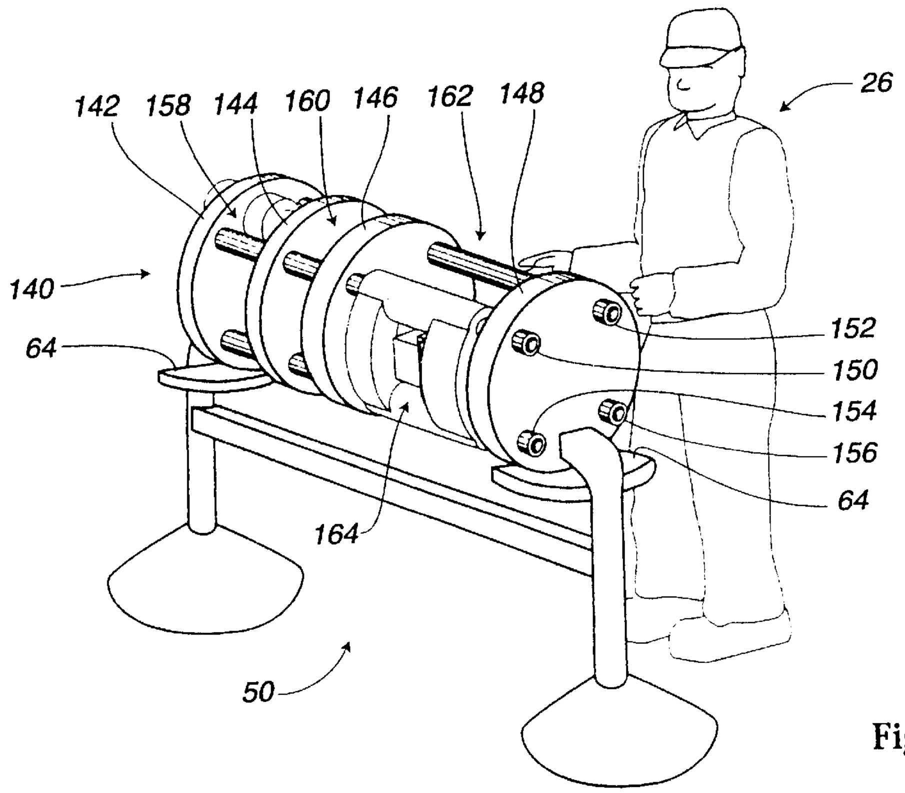
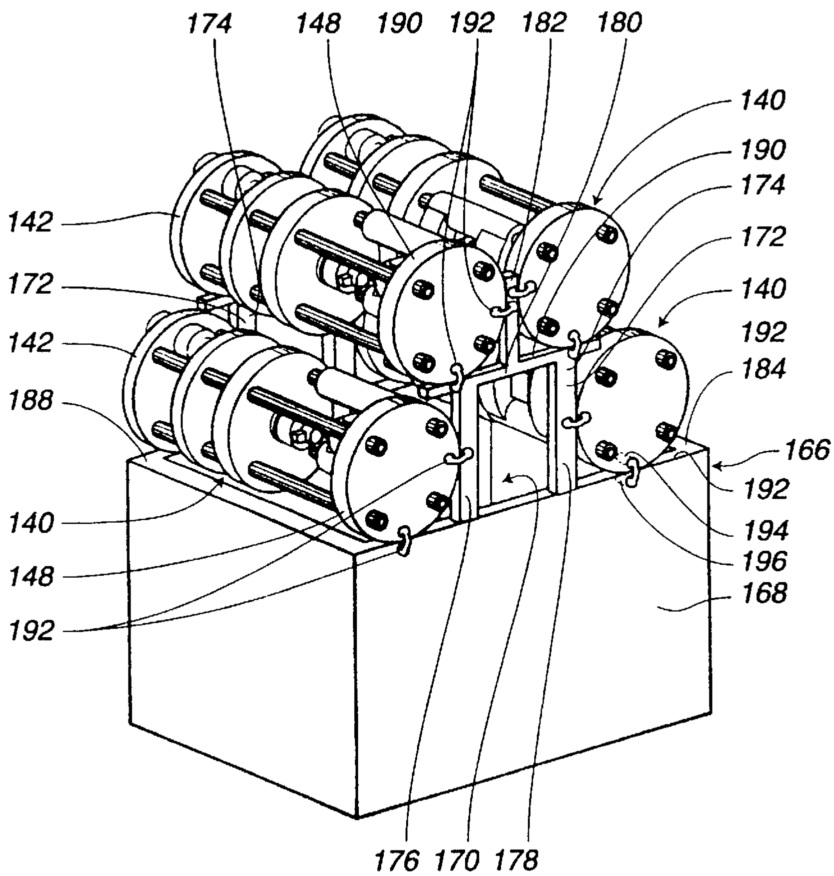
58
60
54

Fig. 8



142
158
144
160
146
162
148
26
140
64
152
150
154
156
64
164
50

Fig. 9



174
148
190
192
182
180
140
190
174
172
140
192
184
142
172
142
188
166
192
194
196
168
140
148
192
176
170
178

Fig. 11

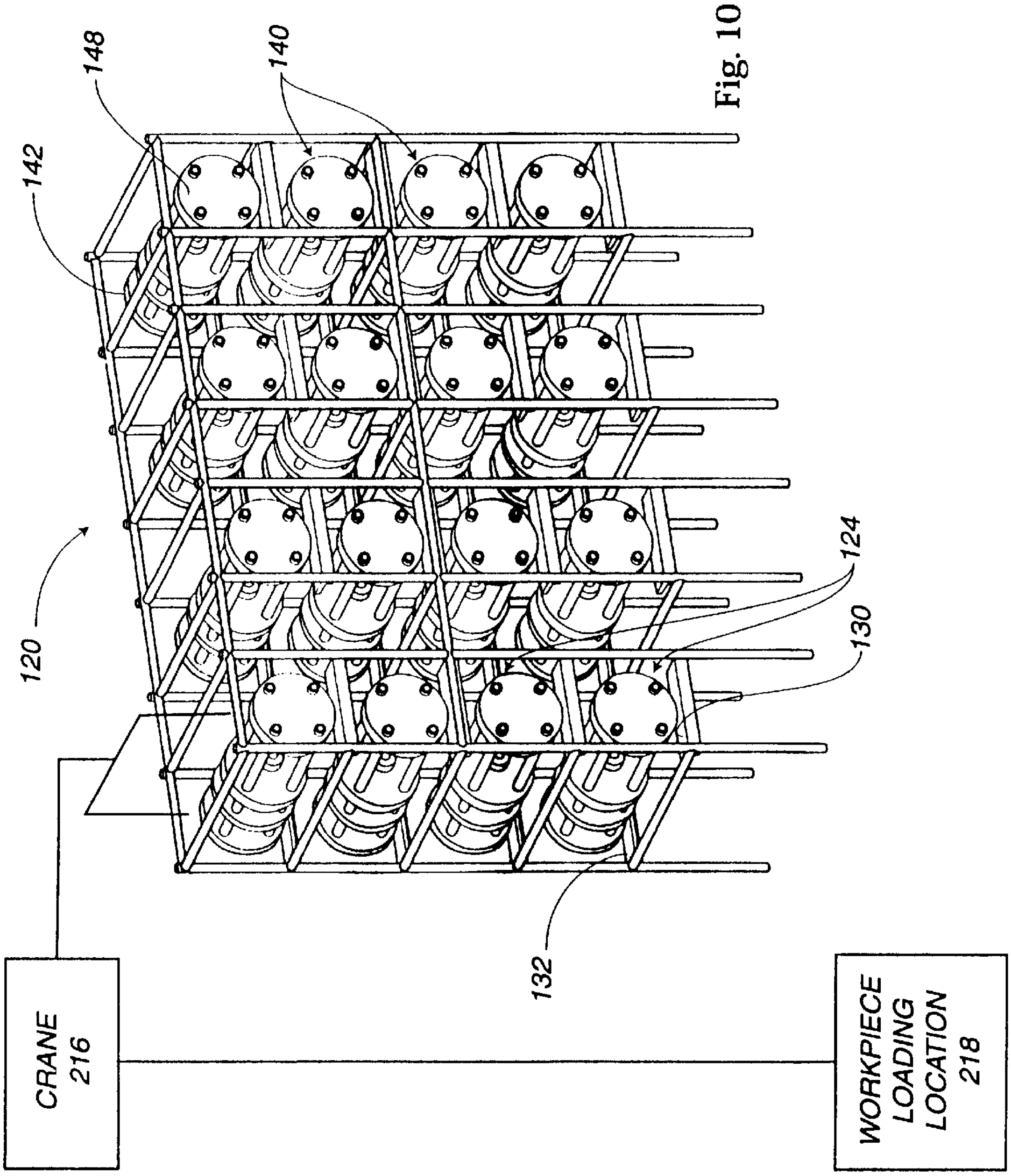

148
140
142
120
124
130
132
CRANE
216
WORKPIECE
LOADING
LOCATION
218

Fig. 10

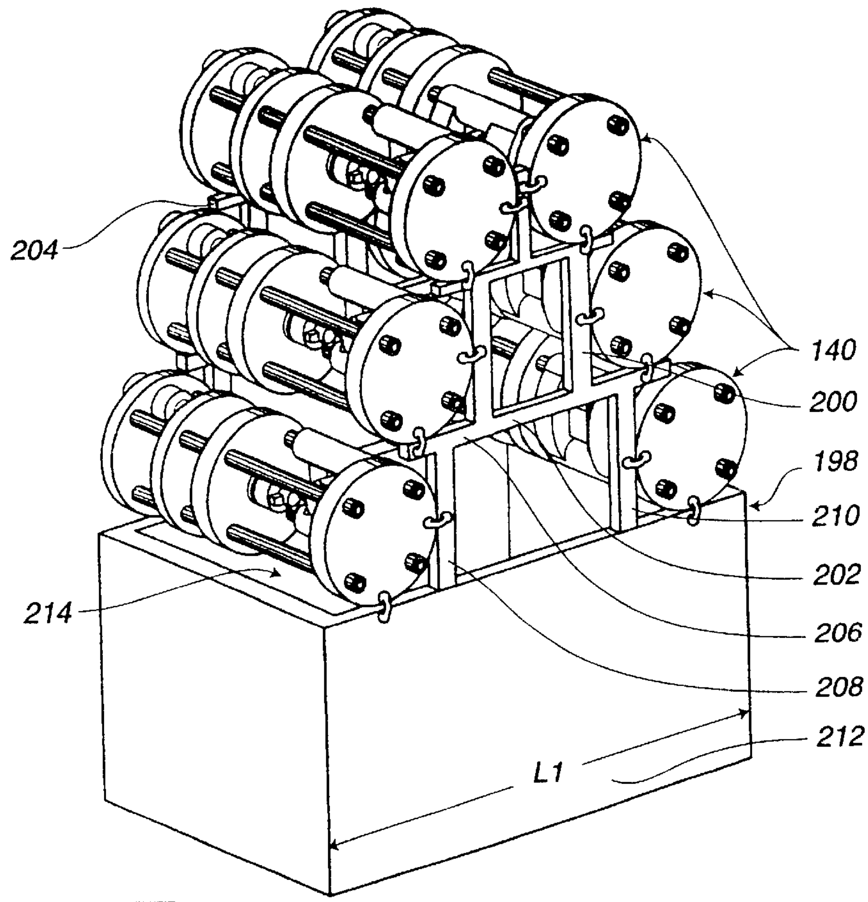


Fig. 12

REMOVE MACHINE TOOL ASSEMBLY FROM BASE

PLACE MACHINE TOOL ASSEMBLY AT LOADING LOCATION

LOAD WORK-PIECE ONTO MACHINE TOOL ASSMBLY

PLACE MACHINE TOOL ASSEMBLY ON BASE

PERFORM MACHINING OPERATION

REMOVE WORKPIECE FROM MACHINE TOOL ASSEMBLY

Fig. 13

MACHINE TOOL ASSEMBLY AND METHOD OF PERFORMING MACHINING OPERATIONS USING THE MACHINE TOOL ASSEMBLY

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to machine tool assemblies for performing machining operations on a workpiece.

2. Background Art

In machining facilities, it is desirable to have the capability to perform multiple machining operations in an efficient manner while minimizing space requirements for the machining equipment. Typically, machine tool assemblies are arranged on a floor on one level. Most commonly, the machine tool assemblies are oriented horizontally. Floor space planning is carried out with the understanding that the footprint of each horizontally situated machine tool assembly will dictate the amount of floor space required for a particular machine tool assembly. Space above the footprint that is not occupied by the machine tool assembly is for all practical purposes wasted space.

It is known to orient machine tool assemblies vertically to better utilize vertically available space. One example of such an arrangement is shown in my co-pending application U.S. Ser. No. 08/759,469, entitled "Automated Machine Tool Including a Plurality of Processing Units". While this arrangement does make a better utilization of vertical space, there are drawbacks with this arrangement. First of all, some machine tool assemblies may be more prone to deformation if oriented in other than a horizontal direction. That is, many systems are configured in a pyramidal construction so that stability and accuracy is maintained by building components with decreasing mass from the base up. The vertical orientation of this type of machine tool assembly may cause the misalignment of cooperating compartments that could detract from system performance.

As with the horizontal systems, the space above the vertically oriented individual machine tool assemblies is for all practical purposes wasted.

While ideally many machining operations are performable simultaneously under one roof, the number of such operations is generally limited by the surface area of a floor on which the machine tool assemblies are supported.

SUMMARY OF THE INVENTION

In one form, the invention is directed to the combination of at least a first base, a first machine tool assembly placed in an operative position on the at least first base, and a second machine tool assembly placed in an operative position on the at least first base above the first machine tool assembly.

In one form, a single base supports both the first and second machine tool assemblies in the operative positions.

In one form, the single base has a stepped frame with a first surface for supporting the first machine tool assembly in the operative position and a second surface above the first surface for supporting the second machine tool assembly in the operative position.

The at least first base may include a first surface for supporting the first machine tool assembly in the operative position and a second surface above the first surface for supporting the second machine tool assembly in the operative position.

In one form, with the first and second machine tool assemblies in the operative positions, the second machine tool assembly is situated vertically directly above the first machine tool assembly.

In one form, the at least first base has a frame with a portion that extends fully around the first machine tool assembly with the first machine tool assembly in the operative position.

In one form, the at least first base has a stepped construction defining a first surface for supporting the first machine tool assembly in the operative position and a second surface above the first surface for supporting the second machine tool assembly in the operative position.

The at least first base may have at least one frame that defines a plurality of compartments each for receiving a machine tool assembly.

In one form the plurality of compartments includes a first compartment, a second compartment spaced fully horizontally from the first compartment, and a third compartment spaced fully vertically from at least one of the first and second compartments.

In one form, the at least first base has first and second spaced, upwardly facing surface portions for cooperatively supporting the first machine tool assembly in the operative position.

A releasable connector may be attached to the frame and the first machine tool assembly to maintain the first machine tool assembly in the operative position.

In one form, the at least first base defines an upwardly opening receptacle and the first machine tool assembly in the operative position resides over the receptacle so that machining lubricant and particles removed from a workpiece on which a machining operation is performed by the first machine tool assembly can be collected.

In one form, the at least first base has a peripheral wall defining the upwardly opening receptacle and the peripheral wall has an upwardly facing surface defined by first and second spaced surface portions which support the first machine tool assembly in the operative position.

A releasable connector may be attached to the peripheral wall and the first machine tool assembly to maintain the first machine tool assembly in the operative position.

The invention is also directed to a method of performing machining operations, which method includes the steps of providing at least a first base having a first surface, providing a first machine tool assembly, with the first machine tool assembly in a first location preparing the first machine tool assembly for the performance of a machining operation on a first workpiece, with the first machine tool assembly prepared for the performance of a machining operation on the first workpiece relocating the first machine tool assembly from the first location to an operative position on the first surface, and performing a machining operation on the first workpiece with the first machine tool assembly with the first machine tool assembly in the operative position.

In one form, the at least first base includes a second surface. The method may further include the steps of providing a second machine tool assembly, with the second machine tool assembly in a second location preparing the second machine tool assembly for the performance of a machining operation on the second workpiece, with the second machine tool assembly prepared for the performance of a machining operation on the second workpiece relocating the second machine tool assembly from the second location to an operative position on the second surface, and performing a machining operation on the second workpiece with the second machine tool assembly with the second machine tool assembly in the operative position.

The method may further include the step of accumulating machining lubricant and/or particles removed from the first workpiece by the first machine tool assembly during a machining operation.

In one form, the second surface resides above the first surface.

In one form, the at least first base has a frame. The method may further include the step of using a connector to releasably connect the first machine tool assembly to the frame.

In one form, the frame defines first and second compartments and the first and second machine tool assemblies reside one each in the first and second compartments with the first and second machine tool assemblies in the operative positions.

The method may further include the step of connecting the first machine tool assembly to the second machine tool assembly with the first and second machine tool assemblies in the operative positions.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a conventional machine tool assembly;

FIG. **2** is a side elevation view of the machine tool assembly of FIG. **1**;

FIG. **3** is a perspective view of a machine tool assembly according to the present invention;

FIG. **4** is a side elevation view of the machine tool assembly of FIG. **3**;

FIG. **5** is a perspective view showing two of the machine tool assemblies of FIGS. **3** and **4** operatively mounted upon one form of base, according to the present invention;

FIG. **6** is a reduced, perspective view of a modified form of base, according to the present invention and with a plurality of machine tool assemblies as in FIGS. **3** and **4** mounted thereto in an operative position;

FIG. **7** is a reduced, perspective view of a further modified form of base, according to the present invention, with a plurality of machine tool assemblies as in FIGS. **3** and **4** in an operative position thereon;

FIG. **8** is a perspective view of a still further modified form of base, according to the present invention, with a machine tool assembly as in FIGS. **3** and **4** in an operative position thereon;

FIG. **9** is a view as in FIG. **8** with a modified form of machine tool assembly, according to the present invention;

FIG. **10** is a reduced, perspective view of a base as in FIG. **7** with a plurality of machine tool assemblies as in FIG. **9** in an operative position thereon;

FIG. **11** is a perspective view of a modified form of base, according to the present invention, with a plurality of modules as in FIG. **9** operatively connected thereto;

FIG. **12** is a perspective view of a still further modified form of base, according to the present invention, with a plurality of modules as in FIG. **9** in an operative position thereon; and

FIG. **13** is a flow diagram showing steps that can be used to perform a machining operation according to the present invention and using one of the inventive bases in FIGS. **5**–**12**.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring initially to FIGS. **1** and **2**, a conventional machine tool assembly is shown at **10** and consists of a base **12** which is supported on a subjacent surface **14**. The base **12** in turn supports cooperating machine tool components, in this case a workpiece holder **16** and a machining unit **18** which cooperate to perform a machining operation on a workpiece **20**.

Conventionally, the height of the base **12**, as indicated by the double-headed arrow **22**, is selected to approximate the height of the waist region **24** of an operator **26**, as indicated by the double-headed arrow **28**. The vertical dimension H may be on the order of 30 inches or more. Typically, the machine tool assembly **10** is constructed in a pyramidal fashion, with the components stacked serially, one on top of the other and upon the base **12**, with the stacked components decreasing in mass from bottom to top. The base **12** has a plan profile, in this case defined by the perimeter of an upwardly facing support surface **30**, that is significantly larger than the combined footprint for the workpiece holder **16** and machining unit **18**. By building the components in this manner, structural stability is sought so as to maintain alignment between the workpiece holder **16** and machining unit **18**. At the same time the mass of the base **12** is dictated by the height requirements to situate the workpiece holder **16** and machining unit **18** at the waist region of the operator **26**.

The drawback with the large mass of the base **12** is that the base **12** becomes prone to deformation as it is heated during machining operations. While the large size base **12** does give structural stability, it is also more prone to thermal deformation, which may compromise the alignment between the workpiece holder **16** and machining unit **18**.

In FIGS. **3**–**8**, one form of machine tool assembly, according to the present invention, is shown at **40**. The machine tool assembly consists of a workpiece holder **42** and a machining unit **44** which are supported in operative relationship by a primary base **46**. The primary base **46** may have the same footprint as the base **12**, previously described with respect to the machine tool assembly **10**, but has a vertical dimension, indicated by the double-headed arrow **48**, that is less than the height H of the base **12**. For example, the height HI of the primary base **46** may be on the order of 24 inches or less.

It should be understood that the particular machining components shown are only exemplary in nature. The inventive concept can be practiced with virtually any type of machine tool components capable of performing any machining operation.

In one form, the machine tool assembly **40**, as seen in FIG. **8**, can be supported upon a secondary base **50** which includes a frame **52** consisting of uprights **54** united by a horizontal cross piece **56**. Each upright **54** has an enlarged bottom **58** which bears on a subjacent support surface **60**. A platform element **62** defines an upwardly facing surface **64** to bear on a bottom surface **66** of the primary base **46**. With the primary base **46** supported on the surface **64**, inturned ends **68** of the uprights **54** engage, one each, with an end wall **70**, **72** on the primary base **46** for purposes of stability.

With this arrangement, the mass of the primary base **46** can be reduced to make it less susceptible to thermal deformation. By reason of using the secondary base **50**, the machine tool assembly **40** can be situated at a comfortable height for the user **26**.

The low profile machine tool assembly **40** lends itself to various different stacking arrangements. In FIG. **5**, two of the machine tool assembles **40** are shown with their bottom surfaces **66** facially abutted to each other. The abutted machine tool assemblies **40** can in turn be placed upon a

secondary base **74** having a peripheral wall **76** bounding a receptacle **78** for collection of machining lubricant and/or particles removed from the workpieces **20** during a machining operation. The peripheral wall **76** has an upwardly facing surface **80** with spaced, parallel surface portions **82, 84** dimensioned to be spanned by the length L (FIG. **3**) of the primary base **46**. Accordingly, two of the machine tool assemblies **40** can be compactly situated relative to each other upon a single secondary base **74**.

In FIG. **6**, a modified form of secondary base is shown at **90** for supporting a plurality of the machine tool assembles **40** in spaced relationship, both in horizontal and vertical directions. The base **90** consists of a peripheral wall which opens upwardly to define a receptacle **94** for lubricant and/or particles removed from workpieces during the machining process.

The secondary base **90** further includes a frame **95** with a stepped configuration, thereby defining lower, substantially parallel, support surfaces **96, 98** and an upper support surface **100** spaced above the support surfaces **96, 98**. The frame **95** spans parallel, spaced surface portions **102, 104** of an upwardly facing surface **106** at the top of the peripheral wall **92**.

The machine tool assemblies **40** are stacked in an operative position at each side of the frame **95** in like fashion. On one exemplary side of the frame **95,** the lowermost machine tool assembly is situated so that the side surface **108** spans, and is supported by, the surface portions **102, 104** on the peripheral wall **92** with the bottom surface **66** facially abutted to an upwardly extending surface **110** on the frame **95**.

The superjacent machine tool assembly **40** has its side surface **108** abutted to the support surface **98** and its bottom surface **66** abutted to an upwardly extending surface **112** on the frame **95**.

Two of the machine tool assemblies **40** are abutted as in FIG. **5** and supported on the surface **100** at the top of the frame **95**.

With this arrangement, there is an efficient utilization of space vertically above the lowermost machine tool assemblies **40**. With a staggered horizontal arrangement, the machine tool assemblies **40** may be in partial vertical coincidence. A single receptacle **94** defined by the peripheral wall **92** may be used for the multiple machine tool assemblies **40**.

In FIG. **7**, a modified form of secondary base is shown at **120** and consists of at least one frame **122** which defines a series of horizontally and vertically spaced compartments **124**, each nominally matched to the volume of a machine tool assembly **40** and designed to receive a machine tool assembly **40** either in a normal horizontal relationship or with the machine tool assembly **40** reoriented from the horizontal position shown. The frame **122** can be made from tubular material or other material, with each compartment including spaced platform elements **126, 128**, each having an upwardly facing surface **130, 132**, which surfaces are bridged by the bottom surface **66** of the primary base **46**. The ends of the compartments **124** are each bounded by a part of the frame **122** that extends fully around an operating axis for the machine tool assembly **40** therewithin.

In FIGS. **9–12**, the invention is described with respect to a modified form of machine tool assembly, the details of which are described in a separate, application, Ser. No. 09/633,545 which is being filed concurrently herewith and is incorporated herein by reference. Briefly, as seen most clearly in FIG. **9**, the machine tool assembly **140** consists of

a caged module defined by a series of end supports **142, 144, 146, 148** which are united by bar-shaped, elongate, parallel, reinforcing elements **150, 152, 154, 156**, each of which extends fully through, and is connected to, the end supports **142, 144, 146, 148**. Between adjacent end supports **142, 144, 146, 148** are a series of compartments/working spaces **158, 160, 162**, within which machine tool components **164** can be mounted. Again, the particular nature of the machine tool is not critical to the present invention, as the inventive concept can be used with virtually any type of machine tool configuration.

In FIG. **9**, the machine tool assembly **140** is shown mounted to the secondary base **150**, previously described. The end supports **142, 148** are spaced to bear against the upwardly facing platform surface **64**.

In FIG. **11**, a plurality of machine tool assembles **140** are shown mounted to a secondary base **166** which includes a peripheral wall **168** bounding a receptacle **170** for the collection of lubricant and/or particles removed from workpieces by machining. The secondary base **166** includes a frame **172** with spaced frame parts **174** of like construction. Each frame part **174** consists of spaced uprights **176, 178** joined by a cross piece **180**. A single upright **182** projects vertically from the horizontal center of the cross piece **180**. The uprights **176, 178** are supported on an upwardly facing surface **184** at the top of the peripheral wall **168**. The uprights **176, 178** on each frame part **174** are supported on parallel, spaced, surface portions **186, 188** which are spaced from each other a distance equal to the spacing between the endmost end supports **142, 148** on each machine tool assembly **140**.

Accordingly, two machine tool assembly modules **140** are supported on the surface portions **186, 188** through the end supports **142, 148**, which are abuttable thereto. Each of these machine tool assemblies **140** is abuttable, one each, to the uprights **176, 178**.

The cross pieces **180** have upwardly facing surfaces **190** to each engage one of the end supports **142, 148** to support the machine tool assemblies **140** at each side of the uprights **182**.

Removable connectors **192**, each having a U shape with projecting legs **194, 196**, are useable to anchor the machine tool assemblies **140** to the secondary base **166**. As shown, the connectors **192** are pressed into registrable openings in the end supports **142, 148** on the lowermost machine tool assemblies **140** and in the peripheral wall **168** and uprights **176, 178**. Like connectors **192** are used to connect the end supports **142, 148** on the uppermost machine tool assemblies **140** to the cross piece **180** and upright **182**.

In FIG. **12**, a modified form of secondary base is shown at **198**. The secondary base **198** has the same general construction as the secondary base **166** with the exception that a frame **200** has frame parts **202, 204** with an additional cross piece **206** and additional depending uprights **208, 210** which thereby produce an additional step for the inclusion of two additional machine tool assemblies **140**. The length L1 of the peripheral wall **212** defining a receptacle **214** for lubricant particles from machined workpieces is extended to accommodate the additional machine tool assemblies **140**.

In FIG. **10**, the secondary base **120**, previously described with respect to FIG. **7**, is used to support the machine tool assemblies **140** in their operative position in vertically overlying relationship in columns and in horizontally spaced relationship in rows. The surfaces **130, 132** are spaced to match the spacing of the end supports **142, 148** which bear thereagainst with the machine tool assemblies **140** in the operative position within the compartments **124**.

Referring to FIGS. **10** and **13**, one exemplary method of using the invention to perform a machining operation will be described. The machine tool assemblies **140** may initially be in the operative position shown in FIG. **10** or in a storage position. A lift, which may be a crane **216**, or the like, removes the machine tool assemblies **140**, one by one, from the compartments **124** and delivers the same to a first workpiece loading location **218**. At the loading location, workpieces can be placed into an operative position to thereby prepare the machine tool assemblies for the performance of a machining operation. Once the machine tool assembly **140** is prepared to machine the workpiece thereon, the machine tool assembly **140** with the loaded workpiece can be lifted by the crane **216** and placed in one of the compartments **124**, whereupon a machining operation is performed. The machined workpiece can then be removed by either removing the machine tool assembly **140** from its compartment and thereafter removing the workpiece, or by removing the workpiece from the machine tool assembly **140** with the machine tool assembly **140** in the compartment **124**.

With this arrangement, efficient vertical space utilization is possible. Multiple machining operations can be performed in a coordinated fashion and simultaneously for efficient machining.

The foregoing disclosure of specific embodiments is intended to be illustrative of the broad concepts comprehended by the invention.

What is claimed is:

1. In combination:

at least a first base;

a first machine tool assembly placed removably in an operative position on the at least first base; and

a second machine tool assembly placed removably in an operative position on the at least first base above the first machine tool assembly,

the first and second machine tool assemblies each being a self-contained unit capable of holding and performing a processing operation on a workpiece selectively with the first and second machine tool assemblies both separated from the at least first base and in the operative position on the at least first base,

wherein the at least first base comprises a stepped frame with stepped first and second surfaces, the first surface supporting the first machine tool assembly in its operative position,

the second surface supporting the second machine tool assembly in its operative position above the first machine tool assembly and in a manner that the second machine tool assembly is horizontally offset from the first machine tool assembly.

2. In combination:

at least a first base;

a first machine tool assembly placed removably in an operative position on the at least first base; and

a second machine tool assembly placed removably in an operative position on the at least first base above the first machine tool assembly,

the first and second machine tool assemblies each being a self-contained unit capable of holding and performing a processing operation on a workpiece selectively with the first and second machine tool assemblies both separated from the at least first base and in the operative position on the at least first base,

wherein the at least first base defines an upwardly opening receptacle and the first machine tool assembly in the operative position resides over the receptacle so that machining lubricant and particles removed from a workpiece on which a machining operation is performed by the first machine tool assembly can be collected,

wherein the at least first base has a peripheral wall defining the upwardly opening receptacle and the peripheral wall has an upwardly facing surface defined by first and second spaced surface portions which support the first machine tool assembly in the operative position.

3. The combination according to claim **2** wherein the at least first base comprises a stepped frame with stepped first and second surfaces, the first surface supporting the first machine tool assembly in the operative position and the second surface situated above the first surface and supporting the second machine tool assembly in the operative position.

4. The combination according to claim **2** wherein the at least first base comprises a first surface for supporting the first machine tool assembly in the operative position and a second surface above the first surface for supporting the second machine tool assembly in the operative position.

5. The combination according to claim **4** wherein with the first and second machine tool assemblies in the operative positions, the second machine tool assembly is situated vertically directly above the first machine tool assembly.

6. The combination according to claim **1** wherein the at least first base comprises a frame with a portion that extends fully around the first machine tool assembly with the first machine tool assembly in the operative position.

7. The combination according to claim **2** wherein the at least first base has a stepped construction defining a first surface for supporting the first machine tool assembly in the operative position and a second surface above the first surface for supporting the second machine tool assembly in the operative position.

8. The combination according to claim **1** wherein the at least first base comprises at least one frame that defines a plurality of compartments each for receiving a machine tool assembly.

9. The combination according to claim **8** wherein the plurality of compartments comprises a first compartment, a second compartment spaced fully horizontally from the first compartment, and a third compartment spaced fully vertically from at least one of the first and second compartments.

10. The combination according to claim **1** wherein the at least first base comprises first and second spaced upwardly facing surface portions cooperatively supporting the first machine tool assembly in the operative position.

11. The combination according to claim **1** wherein there is a releasable connector which is attached to the frame and the first machine tool assembly, the releasable connector maintaining the first machine tool assembly in the operative position.

12. The combination according to claim **1** wherein the at least first base defines an upwardly opening receptacle and the first machine tool assembly in the operative position resides over the receptacle so that machining lubricant and particles removed from a workpiece on which a machining operation is performed by the first machine tool assembly can be collected.

13. The combination according to claim **1** wherein there is a single base that supports both the first and second machine tool assemblies in the operative positions.

14. In combination:

at least a first base;

a first machine tool assembly placed in an operative position on the at least first base; and

a second machine tool assembly placed in an operative position on the at least first base above the first machine tool assembly,

wherein the at least first base has a peripheral wall and defines an upwardly opening receptacle and the first machine tool assembly in the operative position resides over the receptacle so that machining lubricant and particles removed from a workpiece on which a machining operation is performed by the first machine tool assembly can be collected,

wherein there is a releasable connector which is attached to the peripheral wall and the first machine tool assembly, the releasable connector maintaining the first machine tool assembly in the operative position.

15. The combination according to claim **1** further comprising a third machine tool assembly that is attached to one of the first and second machine tool assemblies.

16. The combination according to claim **1** wherein the at least first base comprises a frame that defines vertically spaced first and second compartments each nominally matched to a single one of the first and second machine tool assemblies.

* * * * *

US006401641B1

(12) **United States Patent**
Miyano

(10) **Patent No.: US 6,401,641 B1**
(45) **Date of Patent: Jun. 11, 2002**

(54) **APPARATUS AND METHOD FOR PRODUCING A PATTERN ON A PIECE OF MATERIAL**

(76) Inventor: **Toshiharu Tom Miyano**, c/o Miyano Machinery USA, Inc., 940 N. Central Ave., Wood Dale, IL (US) 60191

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/567,729**

(22) Filed: **May 10, 2000**

(51) **Int. Cl.**[7] **D05B 21/00**; D05B 27/14

(52) **U.S. Cl.** **112/470.05**; 112/470.06; 112/470.33

(58) **Field of Search** 112/470.06, 470.04, 112/470.05, 470.29, 470.33, 63, 102.5, 475.08, 475.09, 475.18, 475.19, 470.07

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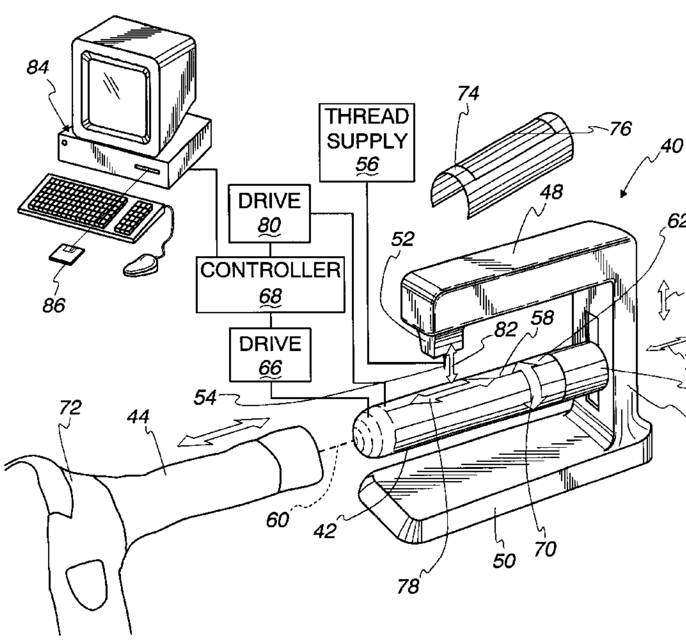
Primary Examiner—Peter Nerbun
(74) *Attorney, Agent, or Firm*—Wood, Phillips, Katz, Clark & Mortimer

(57) **ABSTRACT**

An apparatus for stitching a penetrable material. The apparatus has a support for material to be stitched and a head assembly with a stitching head capable of directing a thread carrying needle through the material to be stitched that is in an operable position on the support to thereby produce a pattern on the material in the operative position. The support has a surface against which a material to be stitched can be placed in the operative position. The surface on the support is movable relative to the stitching head around a first axis to thereby allow material in the operative position that is to be stitched to be repositioned relative to the stitching head.

20 Claims, 2 Drawing Sheets



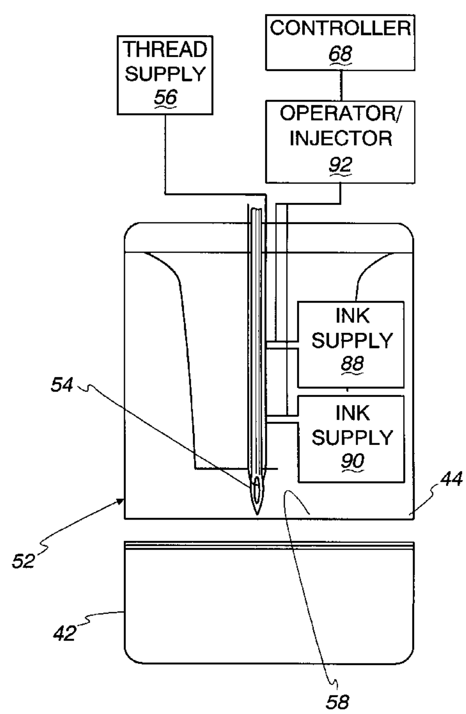


Fig. 1
(Prior Art)

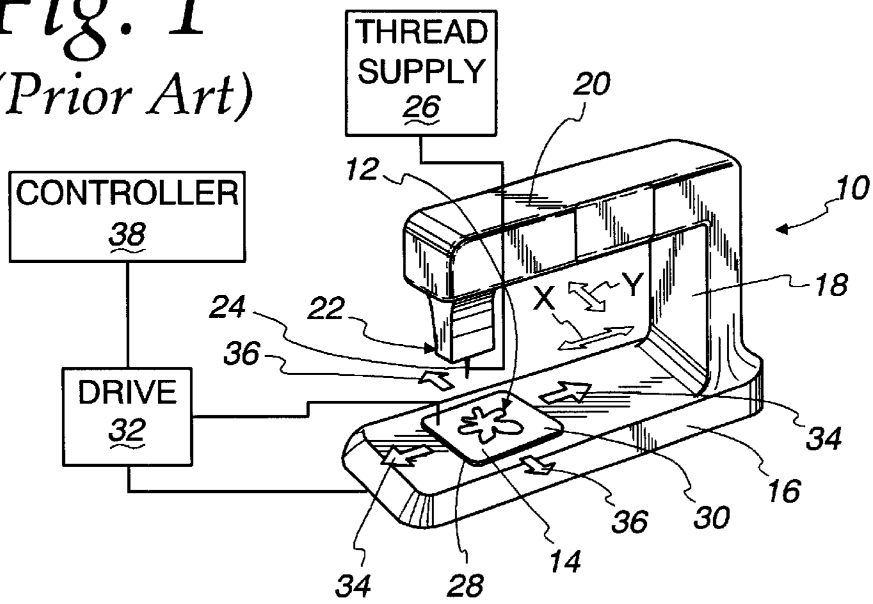
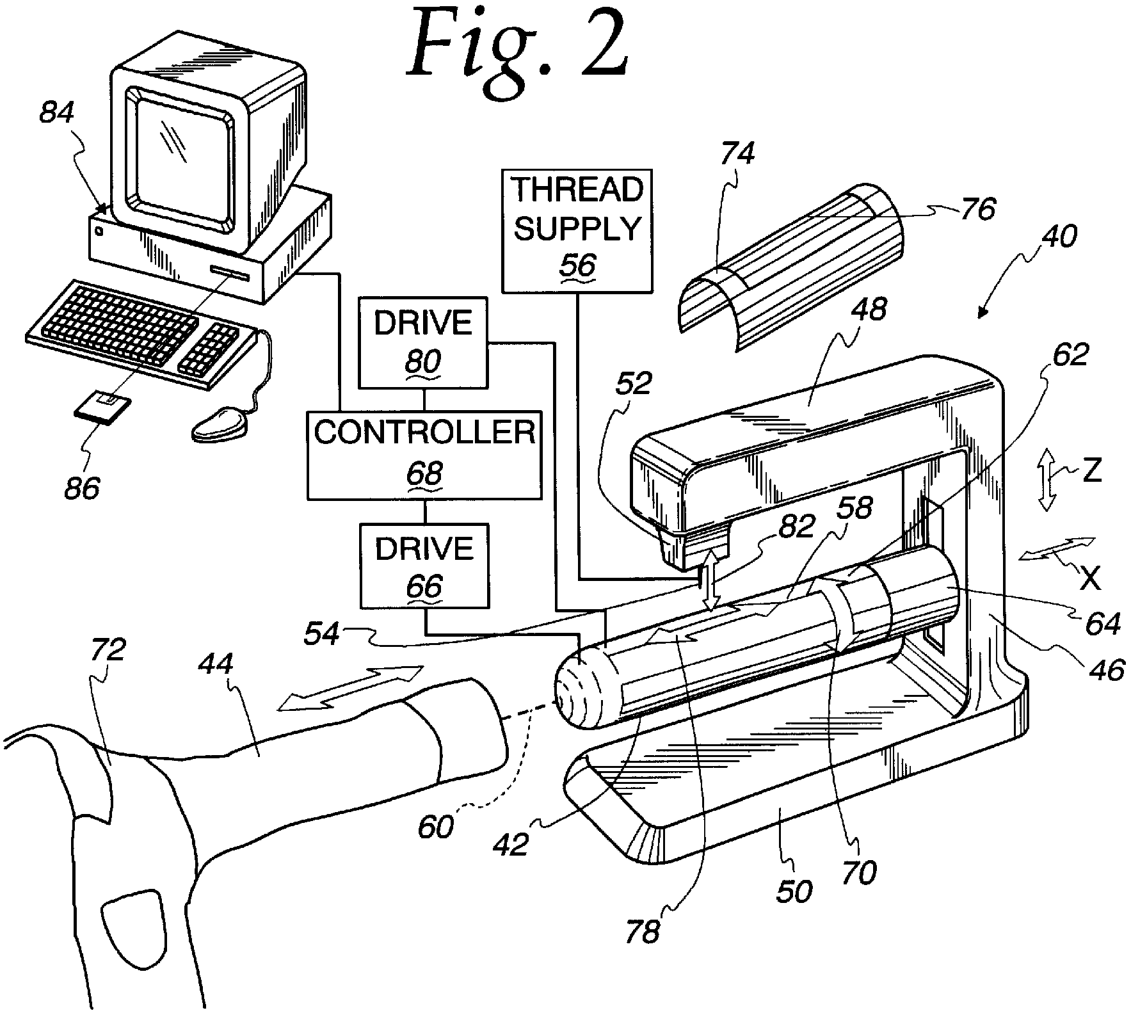


Fig. 2



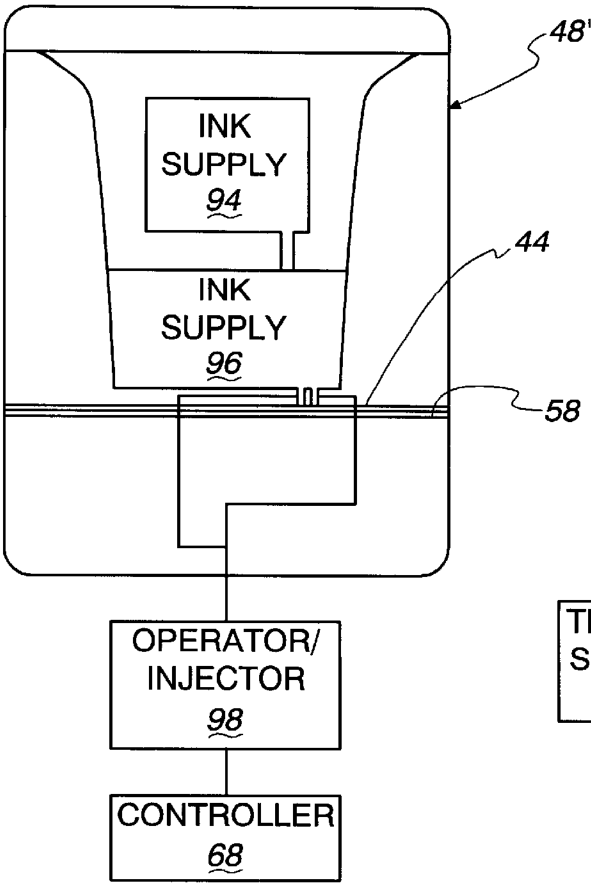

48'
INK SUPPLY 94
INK SUPPLY 96
44
58
OPERATOR/ INJECTOR 98
CONTROLLER 68

Fig. 4

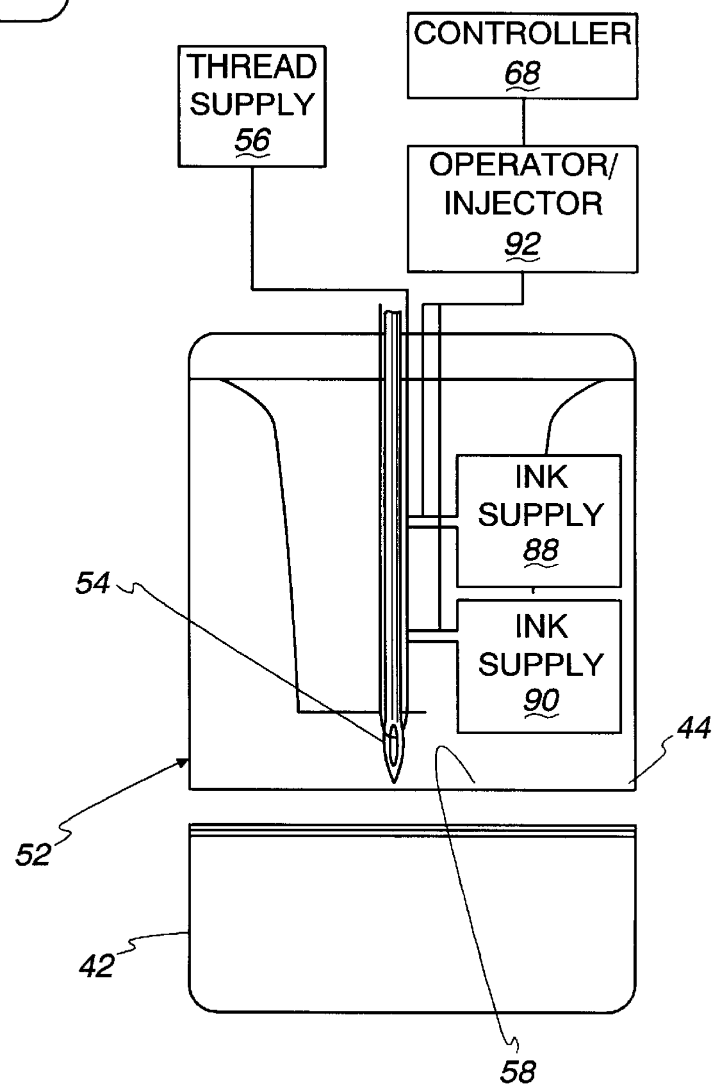

CONTROLLER 68
THREAD SUPPLY 56
OPERATOR/ INJECTOR 92
INK SUPPLY 88
INK SUPPLY 90
54
44
52
42
58

Fig. 3

APPARATUS AND METHOD FOR PRODUCING A PATTERN ON A PIECE OF MATERIAL

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to materials such as flexible fabrics, and the like, and, more particularly, to a method and apparatus for controllably producing a pattern on such material.

2. Background Art

It is well known to controllably produce patterns on flexible material such as cloth, paper, and the like, by stitching using various different colored threads, by the application of a paint or dye thereto, etc. In one form of stitching apparatus, a support is provided for the material in spaced relationship to a stitching head on a head assembly. The material is drawn taut within a continuous bow so that a surface on the material through which stitching is to be carried out resides substantially in a single X-Y plane within the bow perimeter. The stitching pattern is controlled by moving the material in the X-Y plane as the stitching head is operated.

While the above method is effective, it has some inherent drawbacks. The area available for stitching, at any one stage, is limited to that which can be accessed by the stitching head within the bow without interference with the bow.

Some products, by reason of their configuration, do not lend themselves to stitching by this method. For example, stitching on sleeves may be difficult or impossible to carry out by this method. It may not be possible to draw the sleeve taut to permit stitching through only one layer thereof.

Typically, formation of multi-color patterns using the above method requires that different color threads be separately used. This can be accomplished by serially performing stitching operations using separate stitching heads. Alternatively, the thread can be changed in a single stitching head which is operated to serially perform stitching operations.

Typically, this type of equipment has a controller which is pre-programmed to produce desired patterns. The controller may require specifically adapted software which is not usable with a personal computer.

SUMMARY OF THE INVENTION

In one form, the invention is directed to an apparatus for stitching a penetrable material. The apparatus has a support for material to be stitched and a head assembly with a stitching head capable of directing a thread carrying needle through the material to be stitched, that is in an operable position on the support, to thereby produce a pattern on the material in the operative position. The support has a surface against which a material to be stitched can be placed in the operative position. The surface on the support is movable relative to the stitching head around a first axis to thereby allow material in the operative position that is to be stitched to be repositioned relative to the stitching head.

The surface on the support may be convex and may extend through 360° around the first axis.

The surface on the support may be cylindrical.

In one form, the surface on the support is movable in first and second opposite directions relative to the stitching head substantially parallel to the first axis.

The stitching head may be movable relative to the support in first and second opposite directions in a line substantially orthogonal to the first axis.

In one form, the apparatus includes a drive for repositioning the surface of the support relative to the stitching head, a controller for operating the drive, and software for the controller that is PC-compatible.

Ink from a first supply of ink may be applied to the thread directed by the stitching head through the material to be stitched.

In one form, the first supply of ink has a first color. A second supply of ink with a second color may be provided such that the ink from the first and second supplies can be selectively applied to thread directed by the stitching head through the material to be stitched.

The invention is also directed to an apparatus for producing a pattern on a sheet of material having a support for material on which a pattern is to be produced, and a head assembly through which a pattern can be produced on material that is in an operative position on the support. The support has a surface against which a material can be placed in an operative position on the support. The surface on the support is movable relative to the head assembly around a first axis to thereby allow material in the operative position on which a pattern is to be produced to be repositioned relative to the head assembly.

The surface on the support may be convex and may extend through 360° around the first axis.

The surface on the support may be cylindrical.

In one form, the surface is movable in first and second opposite directions substantially parallel to the first axis.

The head assembly may be movable relative to the support in first and second opposite directions in a line substantially orthogonal to the first axis.

The apparatus may further include a drive for repositioning the surface of the support relative to the head assembly, a controller for operating the drive, and software for the drive that is PC-compatible.

A first supply of ink may be provided that can be applied to the material in the operative position on the support to produce a pattern on the material.

In one form, the first supply of ink has a first color and the apparatus includes a second supply of ink having a second color. Ink from the first and second supplies can be selectively applied to material to produce a pattern on the material.

The invention is also directed to a method of producing a pattern on material through a head assembly. The method includes the steps of providing a support with a surface, placing a piece of material against the surface of the support into an operative position, moving the support surface around the first axis, and producing a pattern through the head assembly on the piece of material as the piece of material is moved around the first axis.

The method may include the step, of moving the support surface substantially parallel to the first axis as a pattern is produced through the head assembly on the piece of material.

The method may further include the step of relatively moving the head assembly and support along a line substantially orthogonal to the first axis as the pattern is produced through the head assembly on the piece of material.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic, perspective view of a conventional apparatus for producing a pattern on a piece of material;

FIG. **2** is a perspective view of an apparatus for producing a pattern on a piece of material according to the present invention;

FIG. **3** is an enlarged, schematic, cross-sectional view of a part of a head assembly on the apparatus in FIG. **2**;

FIG. **4** is a view as in FIG. **3** of a modified form of head assembly, according to the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

In FIG. **1**, a conventional apparatus is shown at **10** for producing a pattern **12** on a piece of sheet material **14** which is readily penetrable by a needle. The sheet material **14** may be cloth, paper, or the like. The apparatus **10** consists of a support **16** which connects through an upright **18** to a head assembly **20**. The head assembly **20** includes a stitching head **22** which is capable of reciprocatively driving a needle **24** to stitch thread from a supply **26** through the sheet material **14**. The details of the stitching mechanism and stitching process are well known to those skilled in the art.

The sheet material **14** is drawn taut within the perimeter of a bow **28** so that a surface **30** thereon resides substantially within a plane. The bow **28** is shifted in a predetermined manner by a drive **32** back and forth along the X axis, as indicated by the arrows **34**, and transversely back and forth along the Y axis, as indicated by the arrows **36**. The movement of the drive **32** is dictated by a controller **38** that is operated by a dedicated software program. Various software programs with different pattern control can be purchased and interchanged.

An apparatus for producing a pattern on a piece of material, according to the present invention, is shown at **40** in FIG. **2**. The apparatus **40** consists of a support **42** for a piece of material **44** to be stitched. The support **42** projects in cantilever fashion from an upright **46** which connects between a head assembly **48** and a base **50** so that the upright **46**, head assembly **48**, and base **50** cooperatively define a frame.

The head assembly **48** consists of a stitching head **52** which reciprocates a thread carrying needle **54** along the Z axis in a sewing line. As in the prior art apparatus **10**, the reciprocating movement of the needle **54** causes thread from a supply **56** to be stitched through the piece of material **44**.

The support **42** has a convex surface **58** mounted for movement relative to the stitching head **52** around an axis **60** that is parallel to the X axis. The surface **58** can be mounted in any number of different ways to allow the necessary movement. In this case, an axial end **62** of the support **42** is journalled for rotation in a collar **64** on the upright **46**. The support **42** can be suitably attached to the head assembly **48** and/or base **50** to permit the same movement.

The pivoting movement of the surface **58** around the axis **60** is effected by a drive **66** and is dictated by a controller **68**. This movement is indicated by the double-headed arrow **70**.

With the configuration shown, the piece of material **44** can be placed against the surface **58** in an operative position on the support **42**. In this case, the piece of material **44** is a sleeve on a shirt **72**. The configuration of the surface **58** lends itself to stitching on sleeves which can be placed surroundingly over the support **42**, but is likewise suitable to facilitate stitching on flat material. In the form shown, the convex surface **58** extends through 360° around the axis **60**, but could extend to a lesser degree.

In operation, the surface **58** is directed into the sleeve **44** and the sleeve material drawn taut thereagainst. The sleeve **44** can be suitable fixed by using a spring-type anchor **74** which extends conformingly through preferably in excess 180° around a part of the surface **58** and is grippingly held thereagainst. A spring type material made from metal, plastic, or the like may be used for the anchor **74**. The anchor **74** preferably is dimensioned so that it must be expanded to be placed over the surface **58** such that upon being released it constricts and grips the surfaces **58** thereby maintaining itself in place. The anchor **74** has a working opening **76** therethrough within which a stitching area is defined.

Alternatively, the sleeve **44** can be accumulated and held so as to effectively reduce the diameter thereof to approximately that of the support **42**, whereby the sleeve **44** closely embraces the support **42**, thereby obviating the need to use a separate anchor **74** that frames the area to be stitched.

As a further alternative, one or more magnets can be used to captively hold the material against the support surface **58**.

In operation, the controller **68** causes the drive **66** to strategically pivot the surface **58** around the axis **60** as the stitching head **52** operates the needle **54**. In a preferred form, the surface **58** is also movable relative to the stitching head **52** along the X axis, as indicated by the double-headed arrow **78**. A telescoping connection between the support **42** and collar **64** permits this guided movement, which may be generated by a separate drive **80**, also operated by the controller **68**. Other mechanisms could be devised for the X-axis movement. For example, guided sliding connection can be made between the support **42** and one or both of the head assembly **48** and base **50**. A rack and pinion mechanism can be incorporated to effect the necessary movement of the surface **58**.

Potentially, stitching can occur on substantially the entire axial extent of the surface **58** through approximately 360° around the axis **60**. The controller **68** coordinates movement of the drives **66**, **80** to produce the desired pattern as the stitching head **62** is operated.

It is also possible to connect the support **42** to the upright **46** and/or to the head assembly **48** and base **50** to allow the support **42** to be moved relative to the stitching head **52** in the direction of the Z axis, as indicated by the double-headed arrow **82**.

In one form, the controller **68** may be operable through a personal computer **84** with PC-compatible software **86**.

In FIG. **3**, one form of stitching head **52** is shown in relationship to the support **42** with the surface **58** on which the piece of material **44** is in an operative position. The needle **54** draws the thread from the supply **56** in a predetermined path. Ink from a supply, and in this case two different supplies **88**, **90**, is caused to be selectively applied to the thread **56** from the supply by an operator/injector **92**. The operator/injector **92** may cause ink from the supply **88** alone to be applied to the thread, ink from the supply **90** alone to be applied to the thread, or ink from both supplies **88**, **90** to be applied simultaneously or serially to produce a desired color. This potentially obviates having to use multiple thread supplies **56** or may reduce the number of different thread supplies **56** required.

As one alternative, as shown in FIG. **4**, the pattern **12** may be produced by the application of ink or other dye controllably directly against the piece of material **44**. In this case, one or more ink supplies **94**, **96** may be provided on a head assembly **20'**. Through an operator/injector **98**, ink from the supply **94** and/or supply **96** can be directed to against the piece of material **44** on the surface **58**. The operators/injectors **92**, **98** on the stitching head **52** and head assembly **48'** may be operated by the controller **68** to coordinate the coloring of the thread from the supply **56** and the application of ink from the supplies **94**, **96** with the movement of the surface **58**.

The foregoing disclosure of specific embodiments is intended to be illustrative of the broad concepts comprehended by the invention.

What is claimed is:

1. An apparatus for stitching a penetrable material, said apparatus comprising:

a cantilevered support for material to be stitched; and

a frame comprising an upright and a head assembly projecting from the upright so that the head assembly and upright cooperatively define an L shape;

the head assembly comprising a stitching head capable of directing a thread carrying needle in a sewing line through material to be stitched that is in an operative position on the support to thereby produce a pattern on the material in the operative position,

said cantilevered support comprising a surface against which a material to be stitched can be placed in the operative position,

said surface of the support movable relative to the stitching head around a first axis to thereby allow material in the operative position that is to be stitched to be repositioned relative to the stitching head,

the sewing line extending through the support surface,

the cantilevered support having axially spaced ends arranged so that a cylindrically-shaped workpiece fully separated from the cantilevered support can be directed over one axial end of the cantilevered support and slid toward the other axial end of the cantilevered support into the operative position as far as to the upright.

2. The stitching apparatus according to claim **1** wherein the surface on the support is convex.

3. The stitching apparatus according to claim **1** wherein the surface on the support is cylindrical.

4. The stitching apparatus according to claim **2** wherein the surface on the support is convex through substantially 360° around the first axis.

5. The stitching apparatus according to claim **1** wherein the surface on the support is movable in first and second opposite directions relative to the stitching head substantially parallel to the first axis.

6. An apparatus for stitching a penetrable material, said apparatus comprising:

a cantilevered support for material to be stitched; and

a head assembly comprising a stitching head capable of directing a thread carrying needle in a sewing line through material to be stitched that is in an operative position on the support to thereby produce a pattern on the material in the operative position,

said support comprising a surface against which a material to be stitched can be placed in the operative position,

said surface of the support movable relative to the stitching head around a first axis to thereby allow material in the operative position that is to be stitched to be repositioned relative to the stitching head,

the sewing line extending through the support surface,

the cantilevered support having axially spaced ends arranged so that a cylindrically-shaped workpiece fully separated from the cantilevered support can be directed over one axial end of the cantilevered support and slid toward the other axial end of the cantilevered support into the operative position,

wherein the stitching head is movable relative to the support in first and second opposite directions in a line substantially orthogonal to the first axis.

7. The stitching apparatus according to claim **1** further comprising a drive for repositioning the surface of the support relative to the stitching head, a controller for operating the drive, and software for the controller that is PC-compatible.

8. An apparatus for stitching a penetrable material, said apparatus comprising:

a cantilevered support for material to be stitched;

a head assembly comprising a stitching head capable of directing a thread carrying needle in a sewing line through material to be stitched that is in an operative position on the support to thereby produce a pattern on the material in the operative position,

said support comprising a surface against which a material to be stitched can be placed in the operative position,

said surface of the support movable relative to the stitching head around a first axis to thereby allow material in the operative position that is to be stitched to be repositioned relative to the stitching head,

the sewing line extending through the support surface,

the cantilevered support having axially spaced ends arranged so that a cylindrically-shaped workpiece fully separated from the cantilevered support can be directed over one axial end of the cantilevered support and slid toward the other axial end of the cantilevered support into the operative position; and

a first supply of ink that can be applied to thread directed by the stitching head through material to be stitched.

9. The stitching apparatus according to claim **8** wherein the first supply of ink has a first color and further comprising a second supply of ink having a second color and ink from the first and second supplies can be selectively applied to thread directed by the stitching head through material to be stitched.

10. An apparatus for producing a pattern on a sheet of material, said apparatus comprising:

a support for material on which a pattern is to be produced; and

a head assembly through which a pattern can be produced on material that is in an operative position on the support so that a location at which a pattern is produced on a material in the operative position resides directly between the head assembly and support surface,

said support comprising a surface against which a material can be placed in the operative position on the support,

the surface on the support movable relative to the head assembly around a first axis to thereby allow material in the operative position on which a pattern is to be produced to be repositioned relative to the head assembly,

the surface on the support movable translatingly along first and second lines that are transverse to each other.

11. The apparatus for producing a pattern according to claim **10** wherein the surface on the support is convex.

12. The apparatus for producing a pattern according to claim **11** wherein the surface on the support is cylindrical.

13. The apparatus for producing a pattern according to claim **11** wherein the surface on the support is convex through substantially 360° around the first axis.

14. An apparatus for producing a pattern on a sheet of material, said apparatus comprising:

a support for material on which a pattern is to be produced; and

a head assembly through which a pattern can be produced on material that is in the operative position on the support,

said support comprising a surface against which a material can be placed in an operative position on the support,

the surface on the support movable relative to the head assembly around a first axis to thereby allow material in the operative position on which a pattern is to be produced to be repositioned relative to the head assembly,

the surface on the support movable translatingly along first and second lines that are transverse to each other,

wherein the surface is movable in first and second opposite directions substantially parallel to the first axis.

15. The apparatus for producing a pattern according to claim **10** wherein the head assembly is movable relative to the support in first and second opposite directions in a line substantially orthogonal to the first axis.

16. The apparatus for producing a pattern according to claim **10** further comprising a drive for repositioning the surface of the support relative to the head assembly, a controller for operating the drive, and software for the drive that is PC-compatible.

17. The method of producing a pattern on material according to claim **1** further comprising an anchor which maintains a workpiece against the support surface.

18. The method of producing a pattern on material according to claim **17** wherein the anchor is a spring-type anchor that grips the support surface.

19. An apparatus for stitching a penetrable material, said apparatus comprising:

a cantilevered support for material to be stitched; and

a head assembly comprising a stitching head capable of directing a thread carrying needle in a sewing line through material to be stitched that is in an operative position on the support to thereby produce a pattern on the material in the operative position,

said support comprising a surface against which a material to be stitched can be placed in the operative position,

said surface of the support movable relative to the stitching head around a first axis to thereby allow material in the operative position that is to be stitched to be repositioned relative to the stitching head,

the sewing line extending through the support surface,

the cantilevered support having axially spaced ends arranged so that a cylindrically-shaped workpiece fully separated from the cantilevered support can be directed over one axial end of the cantilevered support and slid toward the other axial end of the cantilevered support into the operative position,

wherein the apparatus comprises a frame consisting of the stitching head, a base, and an upright connecting between the base and the stitching head and the cantilevered support is mounted on the frame for guided movement relative to the frame in a vertical direction transversely to the first axis.

20. The apparatus for stitching a penetrable material according to claim **19** wherein the cantilevered support is mounted on the upright.

* * * * *

US006446533B2

(12) **United States Patent**
Miyano

(10) **Patent No.: US 6,446,533 B2**
(45) **Date of Patent: Sep. 10, 2002**

(54) **LATHE ASSEMBLY AND METHOD OF USING A LATHE ASSEMBLY**

(76) Inventor: **Toshiharu Tom Miyano**, c/o Miyano Machinery USA Inc., 940 N. Central Ave., Wood Dale, IL (US) 60191

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/378,645**

(22) Filed: **Aug. 20, 1999**

(51) **Int. Cl.**[7] **B23B 13/00**; B23B 25/06

(52) **U.S. Cl.** **82/127**; 82/124; 82/126; 82/173

(58) **Field of Search** 82/127, 125, 126, 82/124, 1.11, 46, 47, 48; 414/14, 17, 18

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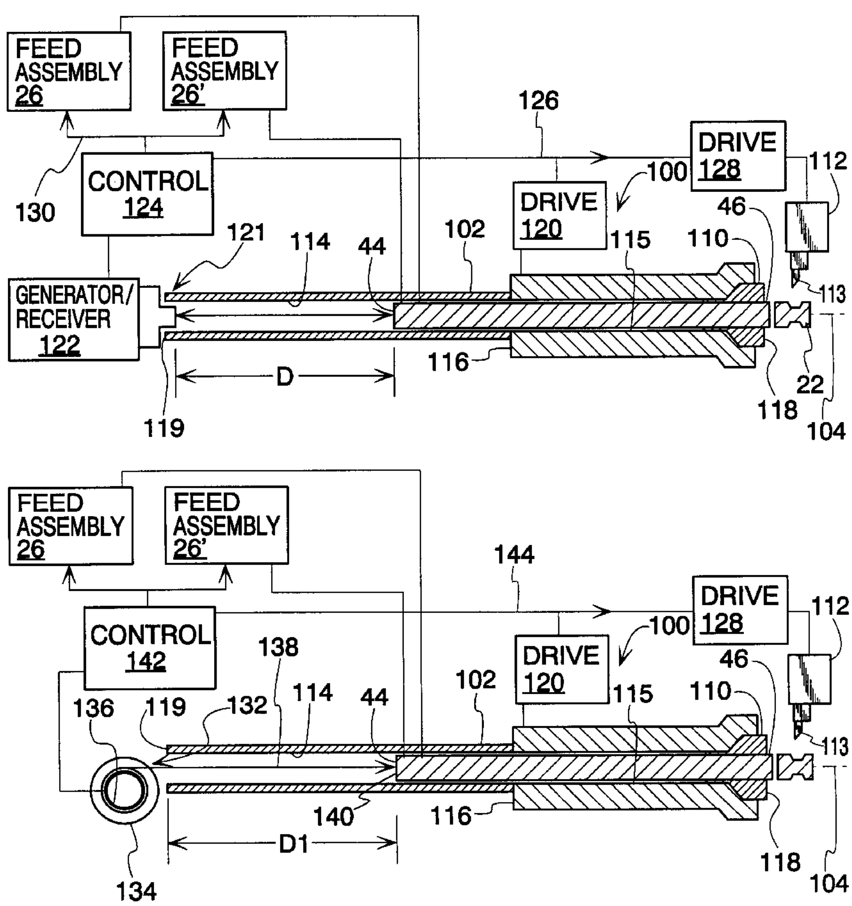
Primary Examiner—Henry Tsai
(74) *Attorney, Agent, or Firm*—Wood, Phillips, Katz, Clark & Mortimer

(57) **ABSTRACT**

A lathe assembly having a guide with a passageway for movement of a piece of bar stock, with a leading end and a trailing end, in a substantially straight path between a feeding position and a working position. A sensor assembly is capable of detecting the position of the trailing end of a piece of bar stock within the guide passageway to thereby allow a user to determine if a piece of bar stock in the guide passageway has a length sufficient to perform the desired operation thereon. Also, a method of using the lathe assembly.

21 Claims, 4 Drawing Sheets



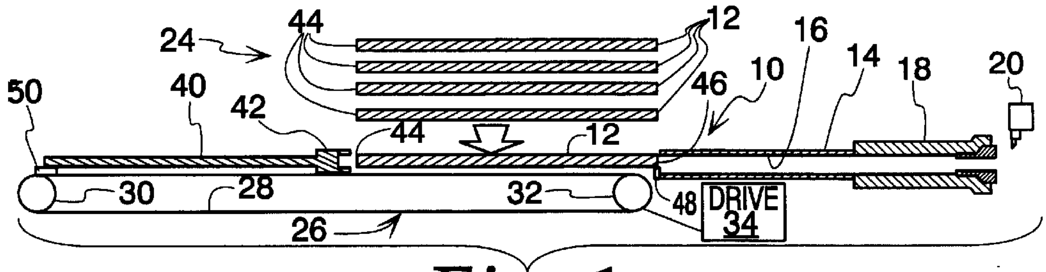


Fig. 1 (PRIOR ART)

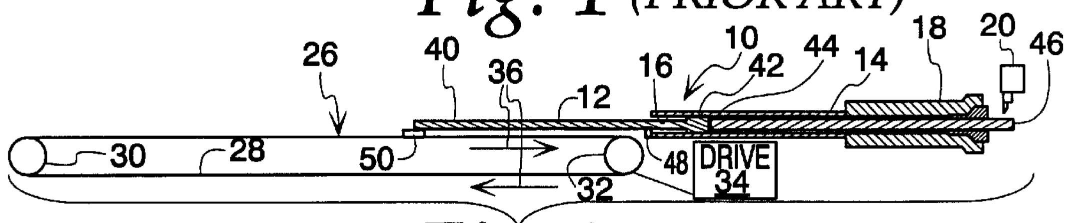


Fig. 2 (PRIOR ART)

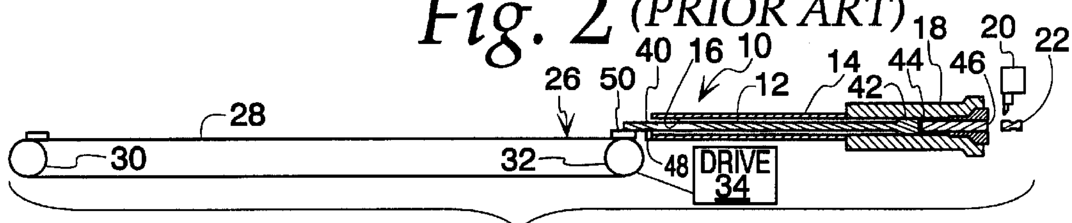


Fig. 3 (PRIOR ART)

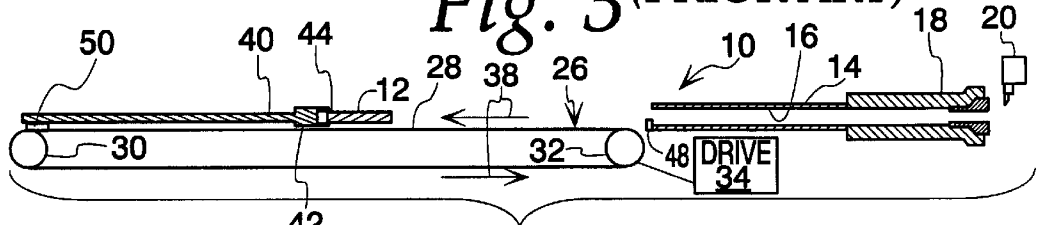


Fig. 4 (PRIOR ART)

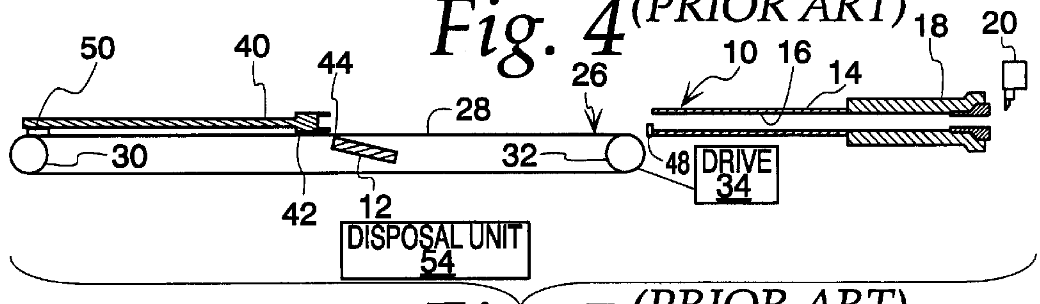
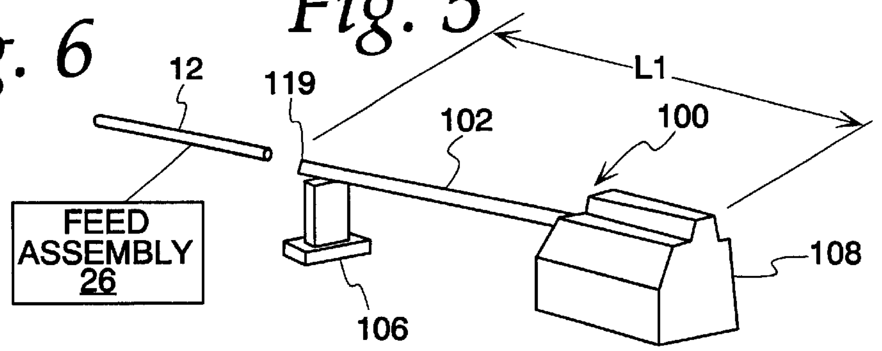


Fig. 5 (PRIOR ART)

Fig. 6



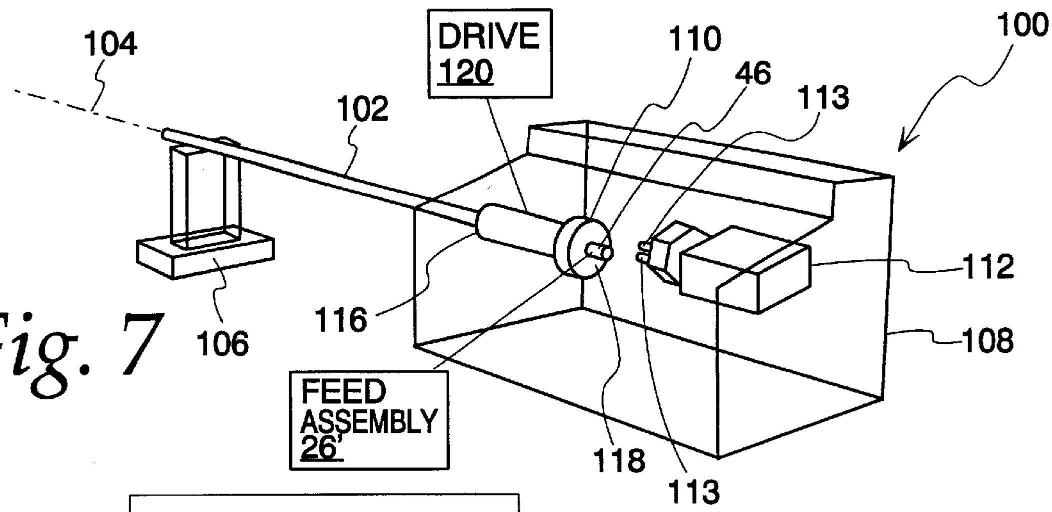


Fig. 7

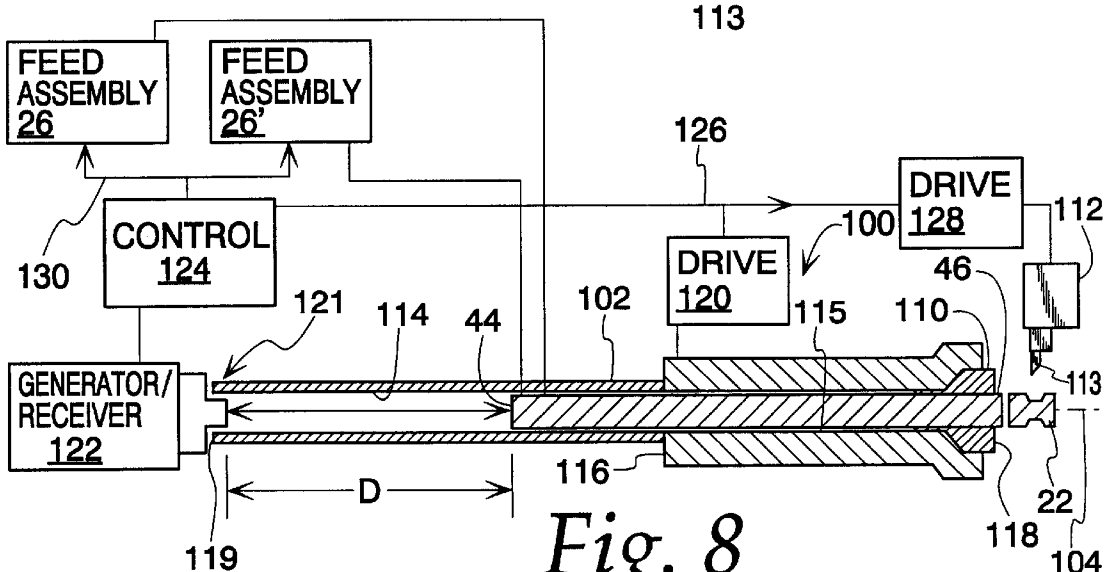


Fig. 8

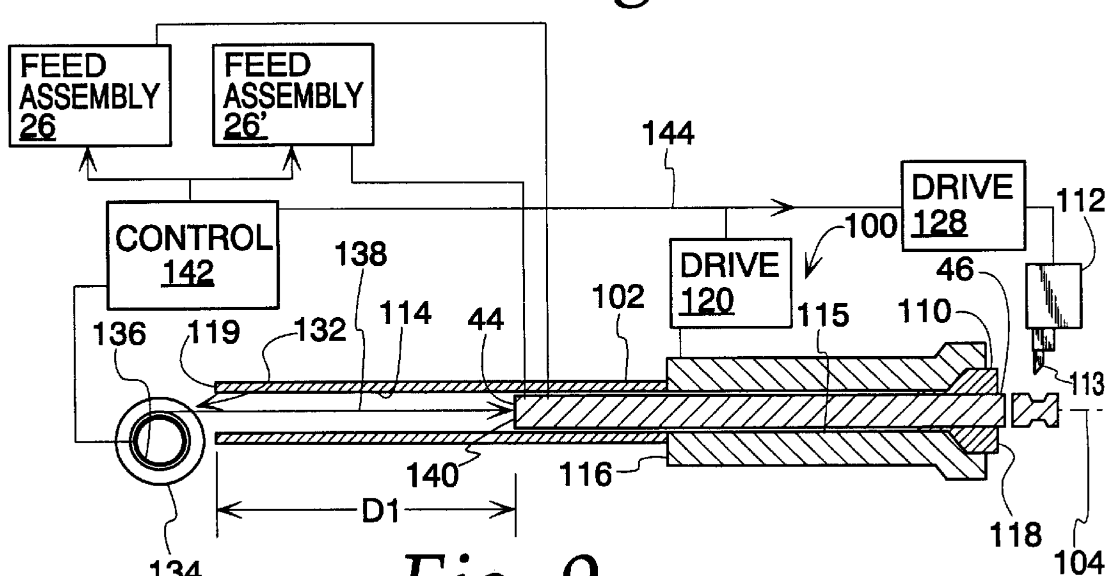


Fig. 9

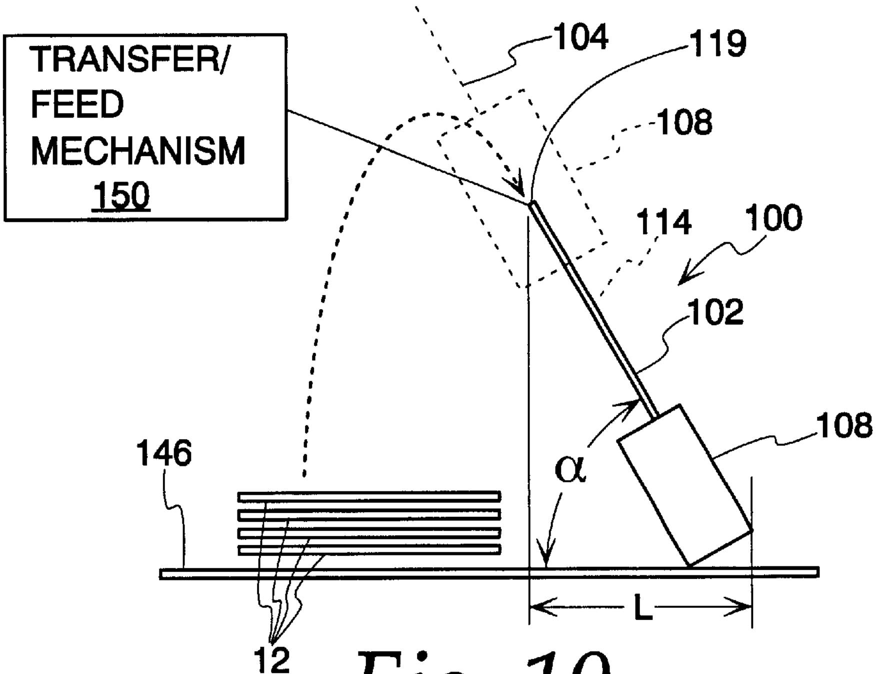

TRANSFER/
FEED
MECHANISM
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Fig. 10

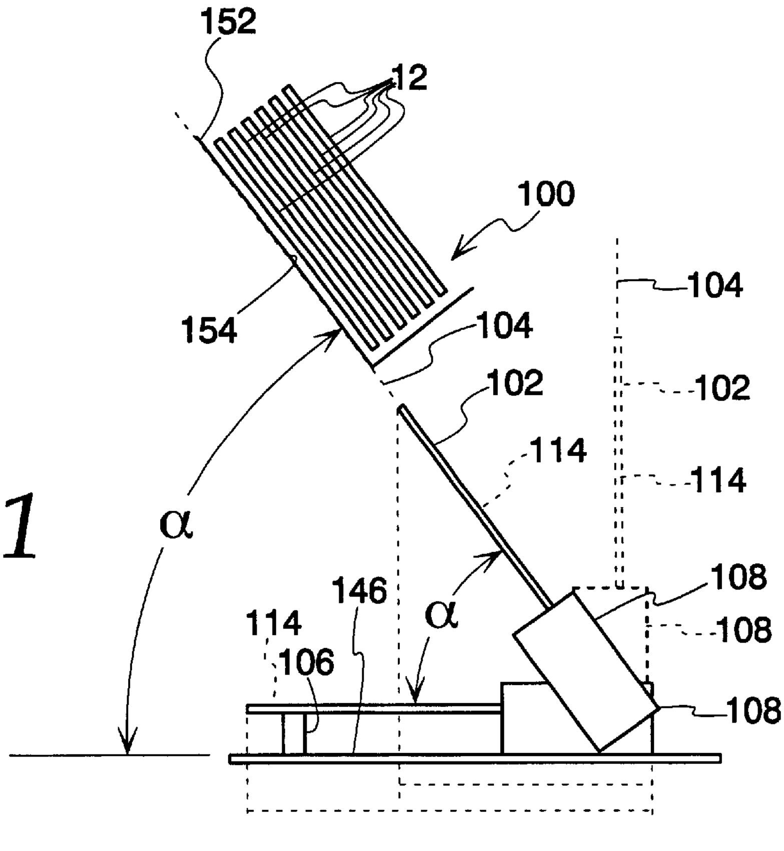
152
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Fig. 11

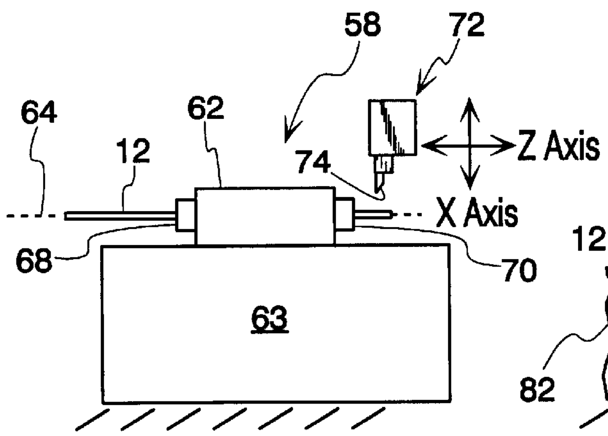

Fig. 12
(PRIOR ART)

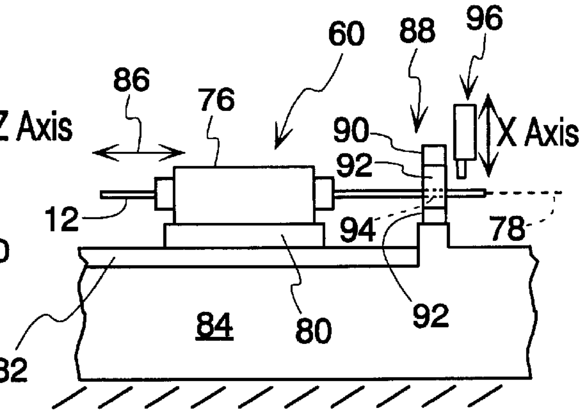

Fig. 13
(PRIOR ART)

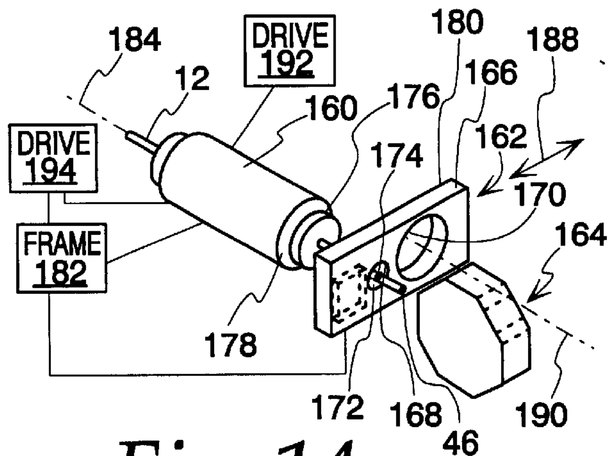

Fig. 14

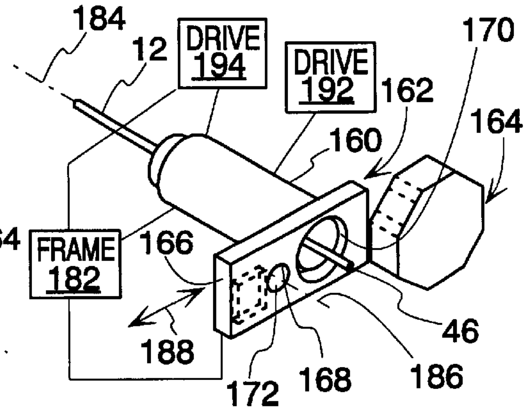

Fig. 15

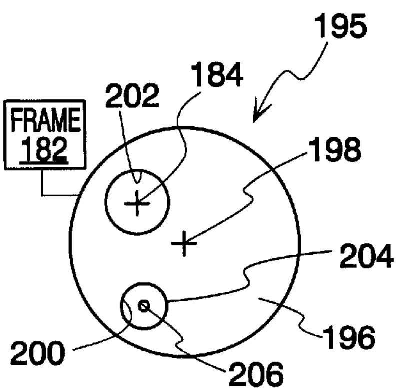

Fig. 18

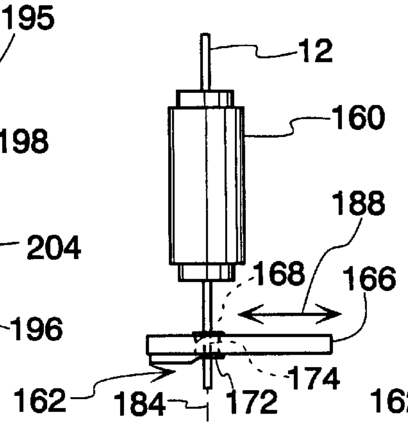

Fig. 16

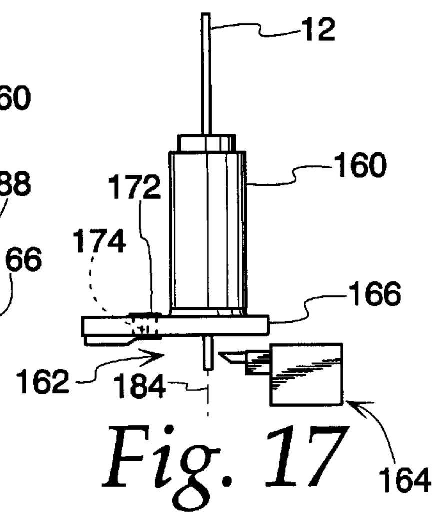

Fig. 17

LATHE ASSEMBLY AND METHOD OF USING A LATHE ASSEMBLY

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to lathe assemblies and, more particularly, to a lathe assembly which performs a machining operation on a piece of bar stock. The invention is also directed to a method of using a lathe assembly.

2. Background Art

It is known to feed bar stock to a tool assembly and to machine the bar stock in successive machining operations to produce multiple, finished workpieces from a single piece of the bar stock. In FIGS. **1–5** herein, a conventional lathe assembly is shown at **10** for operating in this manner upon individual pieces **12** of bar stock.

The lathe assembly **10** consists of a guide **14** defining a passageway **16** within which the individual pieces **12** of bar stock can be guidingly moved selectively towards and away from a spindle **18**. Through the spindle **18**, the pieces **12** of bar stock can be held in a working position, as shown in FIG. **2**, and rotated. A tool assembly **20** performs machining operations on the pieces **12** of bar stock in the working position to produce individual workpieces **22**.

The pieces **12** of bar stock are delivered to the passageway **16** from a supply location at **24** through a feed assembly **26**. The feed assembly **26** consists of an endless chain conveyor **28** which is trained around spaced pulleys **30**, **32**. Through a drive **34**, the pulley **32** is rotated selectively in a forward direction, as indicated by the arrows **36** in FIG. **2**, and a reverse direction, as indicated by the arrows **38** in FIG. **4**.

A push rod **40** is attached to the upper surface of the chain conveyor **28** and is movable from left to right, with the drive **34** operated to rotate the pulley **32** in the forward direction, and from right to left, with the drive **34** operated to rotate the pulley **32** in the reverse direction. The push rod **40** has a receiver **42** at an end thereof to grip the trailing ends **44** of the pieces **12** of bar stock.

In operation, the pieces **12** of bar stock are delivered one-by-one from the supply location **24** to the top surface of the chain conveyor **28** with the push rod **40** retracted to the FIG. **1** position. The drive **32** is then activated to rotate the pulley **32** in the forward direction which causes the receiver **42** to advance from left to right and engage the trailing end **44** of the active piece **12** of bar stock. Continued operation of the drive **34** causes the leading end **46** of the active piece **12** of bar stock to be directed into and through the passageway **16** and spindle **18** to be exposed outside of the spindle **18**, as shown in FIG. **2**, for operation thereon by the tool assembly **20** to thereby produce a workpiece **22**.

The drive **34** is incrementally operated to advance the active piece **12** of bar stock a distance equal to a predetermined length dimension for the workpiece **22**. Eventually, the length of the active piece **12** of bar stock is diminished to less than the predetermined length of the workpiece **22** that is to be produced. Attempting to machine the remaining piece **12** of bar stock that is shorter than the predetermined length of the workpiece **22** could cause jamming and, in any event, is a wasted step given that the machined workpiece **22** would have to be sorted and discarded.

To avoid the above situation, it is known to use a proximity sensor **48** which detects an element **50** at the trailing end **44** of the active piece **12** of bar stock. The element **50** is strategically situated so that the proximity sensor **48** detects the element **50** once the active piece **12** of bar stock has been reduced to a length less than that necessary to form the workpiece **22**. After the last possible workpiece **22** is formed, the sensor detects the element **50** and causes a signal to be generated that causes the drive **32** to thereby retract the remaining piece **12** of bar stock from the passageway **16** and release it to a disposal unit **54**, as shown in FIG. **5**.

The horizontal arrangement of the guide **14** is typical of conventional lathe assemblies. One problem with this horizontal arrangement is that, with very long workpieces, a significant amount of floor space may be required to operate the lathe assembly.

While it is known to vertically orient elongate workpieces held in a vertically opening chuck on lathe assemblies, the problem of chip buildup on the workpiece and chuck must be contended with.

In FIGS. **12** and **13**, two additional prior art lathe assemblies are shown at **58** and **60**, respectively. The lathe assembly **58** is characterized as a fixed spindle lathe assembly with there being a spindle **62** thereon, fixedly attached to a frame **63** and having a horizontal central axis **64**. An elongate piece **12** of bar stock is advanced from an input end **68** of the spindle **62** through the spindle **62** to and through an output end **70** at which the piece **12** of bar stock is exposed to be machined by a tool assembly **72**. The tool assembly **72** is selectively movable along X and Z axes to allow a tool element **74** on the tool assembly **72** to operate on the piece **12** of bar stock held and rotated by the spindle **62**.

The lathe assembly **60** is characterized as a sliding spindle lathe assembly and includes a spindle **76** with a horizontal central axis **78**. The spindle **76** has an adaptor **80** which cooperates with, and is guided along, a rail **82** on a frame **84** so as to allow the spindle **76** to move in the line of the double-headed arrow **86** parallel to the central axis **78** of the spindle **76**.

In the lathe assembly **60**, a bushing assembly **88** is provided with a body **90** and a bushing **92** having an opening **94** therethrough. The spindle axis **78** is coincident with the central axis for the bushing opening **94**. The bushing assembly **88** serves as a support to rigidify the end of the piece **12** of bar stock that is being machined by a tool assembly **96**.

Typically, both of the lathe assemblies **58**, **60** are designed for relatively small diameter pieces **12** of bar stock. It is conventional to make dedicated machines that function either as a fixed spindle lathe assembly, such as the lathe assembly **58**, or as a sliding spindle lathe assembly, such as the lathe assembly **60**.

SUMMARY OF THE INVENTION

The invention is directed to a lathe assembly having a guide with a passageway for movement of a piece of bar stock, with a leading end and a trailing end, in a substantially straight path between a feeding position and a working position. A sensor assembly is capable of detecting the position of the trailing end of a piece of bar stock within the guide passageway to thereby allow a user to determine if a piece of bar stock in the guide passageway has a length sufficient to perform a desired operation thereon.

The lathe assembly may further include a spindle for releasably holding a piece of bar stock in the working position.

The sensor assembly may have a generator for a signal indicative that a piece of bar stock in the guide passageway has less than a predetermined length.

The lathe assembly may further include a tool assembly to perform an operation on a piece of bar stock in the working position.

The sensor assembly may include a generator for a stop signal indicative that a piece of bar stock in the guide passageway has less than the predetermined length. The lathe assembly may further include a control to receive the stop signal and, in response thereto, prevent performance of an operation by the tool assembly on a piece bar stock in the passageway.

The sensor assembly may include an elongate element that can be directed into the guide passageway to against the trailing end of a piece of bar stock in the passageway to thereby determine whether a piece of bar stock in the guide passageway is less than or greater than the predetermined length.

The sensor assembly may include a generator for a beam to be directed against the trailing end of a piece of bar stock in the guide passageway and reflected therefrom and a receiver for the reflected beam.

The generator may be a laser beam generator.

The lathe assembly may further include a piece of bar stock in the guide passageway.

The lathe assembly may still further include a drive to rotate a piece of bar stock in the working position in the guide passageway.

The tool assembly may include a tool element which acts against a piece of bar stock in the working position. The tool assembly may include a turret with a plurality of interchangeable tool elements.

In one form, the spindle has an axis and axially spaced input and output ends and the piece of bar stock in the working position projects from both the input and output ends of the spindle.

In one form, the passageway has a central axis and axially spaced first and second ends. The spindle is at the first axially spaced end and the second axially spaced end is open to allow introduction of a piece of bar stock into the guide passageway.

The invention is also directed to a method of operating a lathe assembly having a guide with a passageway with a central axis and axially spaced first and second ends, a spindle, and a tool assembly for performing an operation on a piece of bar stock having a length and leading and trailing ends. The method includes the steps of directing a piece of bar stock axially through the guide passageway in a first direction from a feeding position into a working position and directing an element into the guide passageway to detect the position of the trailing end of the piece of bar stock and thereby determine if the piece of bar stock in the guide passageway is less than or greater than the predetermined length.

The method may further include the step of performing an operation on the piece of bar stock with the tool assembly if it is determined that the piece of bar stock has at least the predetermined length.

The method may further include the step of advancing the piece of bar stock in the first direction after performing the operation and again directing the element into the guide passageway to detect the position of the trailing end of the piece of bar stock to again determine if the piece of bar stock in the guide passageway is less than or greater than the predetermined length.

The step of directing an element from the sensor into the guide passageway may involve the step of directing a laser beam into the guide passageway.

The step of directing an element from the sensor into the guide passageway may involve the step of directing an elongate element into the guide passageway.

The method may further include the steps of providing a sensor assembly, generating a stop signal from the sensor assembly indicative that the piece of bar stock has a length less than the predetermined length, and processing the stop signal so that no operation is performed by the tool assembly on the piece of bar stock in the guide passageway.

The invention is also directed to a lathe assembly with a guide having a passageway with a central axis for movement of a piece of bar stock with a leading end and trailing end in a substantially straight path substantially parallel to the central axis of the passageway between a feeding position and a working position, and a spindle for releasably holding a piece of bar stock in the working position and having a through opening with a central axis, an input end, and an output end. The guide is oriented so that the central axis of the passageway is not parallel to a horizontal support surface for the lathe assembly. The passageway and through opening are aligned so that the leading end of a piece of bar stock can move through the passageway to and through the through opening from the input end to the output end to project from the output end with a piece of bar stock in the working position.

The central axes of the passageway and through opening may be substantially parallel to each other and extend substantially orthogonally to a horizontal support surface for the lathe assembly.

In one form, the central axes of the passageway and through opening are substantially parallel to each other and are non-orthogonal to a horizontal support surface for the lathe assembly.

The lathe assembly may further include a tool assembly for performing an operation on a piece of bar stock in the working position.

The invention is also directed to a method of operating a lathe assembly with a guide having a passageway with a central axis and axially spaced first and second ends, a spindle with a through opening having a central axis, an input end and an output end, and a tool assembly for performing an operation on a piece of bar stock having a length, a leading end, and a trailing end. The method includes the steps of orienting the guide so that the central axis of the passageway is inclined relative to a horizontal support surface for the lathe assembly and so that the central axis of the passageway declines from the first end towards the second end of the passageway, directing the leading end of the piece of bar stock into and through the passageway in a first direction from the first end of the passageway towards the second end of the passageway, moving the leading end of the piece of bar stock in the first direction into and through the through opening to a working position wherein the leading end of the bar stock projects from the output end of the spindle, clamping the piece of bar stock in the working position in the spindle, and performing an operation on a portion of the piece of bar stock projecting from the output end of the through opening with the piece of bar stock in the working position.

The method may further include the steps of placing a plurality of pieces of bar stock, each having a length, in a storage position, with the lengths of the plurality of pieces of bar stock being substantially parallel to each other and substantially parallel to a horizontal surface supporting the lathe assembly, removing the plurality of workpieces of bar stock one-by-one from the storage position, and directing the plurality of pieces of bar stock one-by-one into the passageway.

The method may further include the steps of placing a plurality of pieces of bar stock each having a length in a storage position with the lengths of the plurality of pieces of bar stock being substantially parallel to each other and substantially non-parallel to a horizontal surface supporting the lathe assembly, removing the plurality of pieces of bar stock one-by-one from the storage position, and directing the plurality of pieces of bar stock one-by-one into the passageway.

The invention is further directed to a lathe assembly having a spindle for holding an elongate workpiece and having a central axis, and a guide assembly having a body and a guide bushing on the body having a first opening with a central axis. The spindle and guide assembly are selectively repositionable between a) a first relative position wherein the central axis of the spindle extends through the first guide bushing opening so that an elongate workpiece held by the spindle can be projected into the first guide bushing opening so that the guide bushing limits flexing of an elongate workpiece held by the spindle and b) a second relative position wherein the central axis of the spindle does not extend through the first guide bushing opening. The lathe assembly further includes a tool assembly for performing an operation on an elongate workpiece held by the spindle.

In one form, with the spindle and guide assembly in the first relative position, the central axis of the spindle is substantially coincident with the central axis of the first guide bushing opening.

The guide bushing may be rotatable relative to the guide assembly body around the central axis of the first guide bushing opening.

The lathe assembly may further be provided in combination with an elongate workpiece that is held by the spindle and projects into the first guide bushing opening with the spindle and guide assembly in the first relative position.

In one form, the guide assembly has a second opening in the body with a central axis and with the spindle and the guide assembly in the second relative position, the central axis of the spindle extends through the second opening.

In one form, the first guide bushing opening has a first diameter, and the second opening has a second diameter, and the first diameter is different than the second diameter.

The guide assembly may be translatable relative to the spindle as the spindle and guide assembly are repositioned between the first relative position and the second relative position.

The guide assembly may be rotatable about an axis relative to the spindle as the spindle and guide assembly are repositioned between the first relative position and the second relative position.

The spindle and guide assembly may be movable, one relative to the other, along a line substantially parallel to the central axis of the spindle.

In one form, the spindle is abuttable to the guide assembly to be supported by the guide assembly.

In one form, with the spindle and the guide assembly in the second relative position, the central axis of the spindle is substantially coincident with the central axis of the second opening.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic, cross-sectional view of a prior art lathe assembly including a feed assembly for directing pieces of bar stock through a guide passageway to a spindle to be held thereby for operation by a tool assembly and with one of the pieces of bar stock placed on the feed assembly;

FIG. **2** is a view as in FIG. **1** with the feed assembly operated to advance the piece of bar stock through the guide passageway and spindle to a working position wherein it is exposed to be machined by the tool assembly;

FIG. **3** is a view as in FIG. **2** showing the piece of bar stock further advanced and with a workpiece formed and cut from the end of the piece of bar stock;

FIG. **4** is a view as in FIG. **3** wherein the feed assembly is operated to withdraw the remaining portion of the piece of bar stock from the spindle and guide passageway;

FIG. **5** is a view as in FIG. **4** with the remaining piece of bar stock being deposited in a disposal unit;

FIG. **6** is a schematic, perspective view of a lathe assembly according to the present invention;

FIG. **7** is a view as in FIG. **6** showing a spindle and tool assembly on the lathe assembly;

FIG. **8** is an enlarged, schematic, cross-sectional view of a guide defining a passageway, spindle, and a tool assembly for repositioning and advancing a piece of bar stock for operation thereon by a tool assembly on the inventive lathe assembly of FIGS. **6** and **7** and showing one type of structure, according to the present invention, for determining the remaining length of a piece of bar stock in the guide passageway;

FIG. **9** is a view as in FIG. **8** showing another form of structure for determining the remaining length of a piece of bar stock in the guide passageway;

FIG. **10** is a schematic representation of a lathe system, according to the invention, and having a non-horizontal guide passageway for a supply of pieces of bar stock, with the individual pieces being deliverable one-by-one from a supply in which the elongate bar stock is situated horizontally;

FIG. **11** is a view as in FIG. **10** with pieces of bar stock in a supply situated angularly to a horizontal support surface for the lathe assembly for facilitated delivery to the guide passageway, and with a modification of the lathe assembly shown in phantom wherein the guide assembly extends substantially orthogonally to a horizontal support surface for the lathe assembly;

FIG. **12** is a schematic, side elevation view of a conventional lathe assembly having a fixed spindle;

FIG. **13** is a side elevation view of a conventional lathe assembly having a slidable spindle;

FIG. **14** is a perspective view of a spindle in relationship to a guide assembly, according to the invention, and a tool assembly, with the guide assembly and spindle being in a first relative position wherein a piece of bar stock held by the spindle is supported on a bushing on the guide assembly;

FIG. **15** is a view as in FIG. **14** with the spindle and guide assembly repositioned to a second relative position wherein the spindle abuts to the guide assembly and the piece of bar stock is not directly supported by the guide assembly;

FIG. **16** is a fragmentary, plan view of the spindle and guide assembly, according to the invention, arranged to function as a fixed spindle lathe assembly as in FIG. **14**;

FIG. **17** is a fragmentary, plan view of the spindle and guide assembly, according to the invention, arranged to function as a sliding spindle lathe assembly as in FIG. **15**; and

FIG. **18** is an elevation view of a modified form of guide assembly that is useable in conjunction with the spindle in FIGS. **14–17**.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring initially to FIGS. **6–9**, a lathe assembly, according to the present invention, is shown at **100**. The lathe

assembly **100** includes an elongate guide **102** with a central axis **104**. The guide **102** is supported by axially spaced frame elements **106, 108**, with the latter defining a housing for a spindle **110** and a tool assembly **112**, which are operable to perform a machining operation on a piece **12** of bar stock held by the spindle **110**. The tool assembly **112** is a turret-type having interchangeable, and selectively usable, tool elements **113**.

The guide **102** defines a passageway **114** through which pieces **12** of bar stock can be delivered from a feeding position, as shown in FIG. **6**, in a straight path to a working position, as shown in FIGS. **7–9**. The spindle **110** has a through opening **115** with an input end **116** and an output end **118**. The through opening **115** and passageway **114** have coincident central axes. As a piece **12** of bar stock is moved from the feeding position into the working position, the leading end **46** thereof initially enters the passageway **114** at an open axial end **119** thereof, extends along the axis **104** up to and beyond the input end **116** of the spindle **110**, through the spindle **110** and from the output end **118** of the spindle **110** to be exposed adjacent to the tool assembly **112**. The advancement of the piece **12** of bar stock can be effected by a pushing action through the feed assembly **26**, as previously described with respect to claims **1–5**, or by a feed assembly **26**' which grips and pulls the pieces **12** of bar stock from the feeding position into the working position. The spindle **110** may be of any conventional construction.

Once in the working position, the active piece **12** of bar stock is held by the spindle **110** whereupon the appropriate machining operation is carried out by the tool assembly, as the spindle is rotated by a drive **120** around the axis **104**, to produce the finished workpiece **22**. The initial length of the pieces **12** of bar stock can be selected to allow fabrication of numerous of the workpieces **22** from each length thereof. Accordingly, after each machining operation, the feed assembly **26, 26**' can be operated to advance the active piece **12** of bar stock a set distance as dictated by the length of the workpiece **22** to be formed.

According to the invention, the trailing end **44** of a piece **12** of bar stock is monitored to thereby determine whether the remaining length of the piece **12** of bar stock in the guide passageway **114** is sufficient to perform a desired operation thereon by the tool assembly **112**.

To accomplish this, a first type of sensor assembly is shown at **121**. The sensor assembly **121** includes a laser beam generator and receiver **122** which is capable of directing a laser beam at the trailing end **44** of a piece **12** of bar stock and receiving the reflected beam signal. With an appropriate control **124**, an analysis of the impinging and reflecting beams can be made, after each advancing movement of the piece **12** of bar stock, to ascertain the distance D between the laser beam generator/receiver **122** and the trailing end **44** of the piece **12** of bar stock. For a predetermined distance D, the remaining length of the active piece **12** of bar stock will be insufficient to perform an operation to produce a desired workpiece configuration. Upon identifying this predetermined distance, or greater, the control **124** sends a stop signal **126** to a drive **128** for the tool assembly **112** and/or the drive **120** to thereby prohibit operation of the tool assembly **112** on the remaining piece **12** of bar stock. At the same time, or alternatively, the control **124** may send a signal **130** to the feed assemblies **26, 26**' which may cause the feed assemblies **26, 26**' to stop and/or reverse the direction of movement of the remaining piece **12** of bar stock.

In FIG. **9**, an alternative form of sensor assembly is shown at **132**. The sensor assembly **132** includes a drum **134** with a hub **136** around which a wire element **138** is wrapped. The wire element **138** has a free end **140** which can be advanced into the passageway **114** by rotation of the hub **136**. The wire element **138** may be a single wire or a plurality of bundled wires. The wire may be spring wire, piano wire, or the like. The degree of rotation/number of rotations dictates the extension of the wire element **138** within the passageway **114** to allow calculation of the distance D1, which again is correlated to the length of the remaining piece **12** of bar stock.

The rotation of the hub **136** can be detected by a control **142**. Upon sensing the number of revolutions of the hub **136** which extends the wire element to a distance D1 indicative that the length of the remaining piece **12** of bar stock is less than that necessary to produce the desired configuration for the workpiece **22**, the control **142** generates a signal **144** to the drive **128** and/or one or both of the feed assemblies **26, 26**', as previously described.

In FIGS. **10** and **11**, the guide **102** and frame element **108** are shown inclined from the orientation in FIGS. **6–9** relative to a horizontal support surface **146** for the lathe assembly **100**. Whereas the central axis **104** is substantially parallel to the support surface **146** for the lathe assembly **100** in FIGS. **6–9**, in FIGS. **10** and **11**, the axis **104** makes an angle α to the support surface **146**. The angle α may range from a few degrees to 90°, as shown in dotted lines in FIG. **11**.

The effective length L occupied by the guide **102** and frame **108** is reduced from the length L1 (FIG. **6**) with the lathe assembly **100** in the FIG. **6** orientation. Since many facilities in which the lathe assembly **100** would be operated have no significant height restriction, it is possible to reduce the operating area of the floor required for the lathe assembly **100** by angularly situating the guide **102** and housing **108** as in FIGS. **10** and **11**.

In FIG. **10**, the pieces **12** of bar stock are stacked so that the lengths thereof are substantially parallel to each other and the surface **146**. Through an appropriate transfer/feed mechanism **150**, individual pieces **12** of bar stock can be reoriented and directed into the passageway **114** through the open axial end **119** of the guide **102**.

Alternatively, as shown in FIG. **11**, a hopper **152** can be provided for a supply of the pieces **12** of bar stock. The hopper **152** has a guide surface **154** which is situated at an angle α equal to the angle α for the inclination of the guide **102** and frame element **108**. Suitable structure can be provided to discharge the pieces **12** of bar stock one-by-one from the hopper **152** by movement along the guide surface **154**.

A further modification is shown in phantom lines in FIG. **10** wherein the lathe assembly **100** is reversed so that the frame element **108** is above the guide **102**. The individual pieces **12** of bar stock would thus have to be fed against gravitational forces to a working position. This arrangement may be practical at relatively small angles α and for relatively short pieces **12** of bar stock.

In FIGS. **14–17**, a spindle **160** is shown in conjunction with a guide assembly **162** which allows the tool assembly at **164** to perform a machining operation on the piece **12** of bar stock held by the spindle **160** both unsupported, with the fixed spindle arrangement as shown for the lathe assembly **58**, and supported with the sliding spindle arrangement, as shown for the lathe assembly **60**. Typically, this type of lathe assembly is used to produce small diameter parts using bar stock on the order of ⅛–¼ inch as opposed to 3–4 inches for the lathe assembly **100**.

More specifically, the guide assembly has a body **166** with a mounting opening **168** and a second opening **170** therethrough. The mounting opening **168** has a bushing **172** fit therewithin and in turn has an opening **174** therethrough that is slightly greater in diameter than the diameter of the piece **12** of bar stock and of a lesser diameter than the second opening. The second opening **170** is dimensioned to snugly receive a reduced diameter portion **176** of the spindle **160**. With the reduced diameter portion **176** extended into the second opening **170**, an annular surface **178** abuts to a facing surface **180** on the body **166**.

According to the invention, the spindle **160** and body **166** are mounted to a frame **182** for guided movement between a first relative position, as shown in FIG. **14**, and a second relative position as shown in FIG. **15**. In the first relative position, the axis **184** of the spindle **160** extends through the opening **174** and is coincident with the central axis **186** of the opening **174** and the central axis of the piece **12** of bar stock held by the spindle **160**. The bushing **172**, which may be journalled for rotation relative to the body **166**, supports the leading end **46** of the piece **12** of bar stock near the location where it is operated upon by the tool assembly **164**.

By translatingly shifting one or both of the spindle **160** and body **166** relative to the frame **182**, and each other, in the direction of the double-headed arrow **188**, the spindle **160** and guide assembly **162** can be placed in the second relative position, wherein the central axis **184** extends through the opening **170** and coincides with the central axis **190** of the second opening **170**. In the second relative position, the annular surface **178** can be abutted to the surface **180**. The diameter of the second opening **170** is significantly greater than the diameter of the piece **12** of bar stock so that the spindle **160** can be rotated by a drive **192** without there being any interference between the piece **12** of bar stock and the body **166**.

In the first relative position of FIG. **14**, the spindle **160** and tool assembly **164** cooperate in the same manner as the spindle **76** and tool assembly **96** in FIG. **13**. In the second relative position of FIG. **15**, the spindle **160** and tool assembly **164** cooperate in the same manner as the tool assembly **62** cooperates with the tool assembly **72** in FIG. **12**. Thus, it is possible to use a single spindle **160** and a single lathe assembly to operate in both modes disclosed in FIGS. **12** and **13**.

A second drive **194** may also be used to move the spindle **160** relative to the frame **182** along the axis **184**. Additionally, or alternatively, the guide assembly **162** can be moved in the same line relative to the frame **182** and spindle **160**.

In FIG. **18**, a modified form of guide assembly **195** is shown having a body **196** which is rotatable around an axis **198** relative to the frame **182** and spindle **160** between corresponding first and second relative positions.

The body **196** has mounting and second openings **200**, **202** therethrough. By rotating the body. **196** about the axis **198**, the openings **200**, **202** can be repositioned so that the central axes thereof selectively can be brought into coincidence with the axis **184**. The second opening **202** has the same diameter as the opening **170**, with the mounting opening **200** having a corresponding diameter to the first opening **168**. A like bushing **204** can be mounted in the opening **200** and in turn has an opening **206**, corresponding to the opening **174**, to accept the piece **12** of stock material.

The foregoing disclosure of specific embodiments is intended to be illustrative of the broad concepts comprehended by the invention.

What is claimed is:

1. A lathe assembly comprising:

a guide having a passageway for movement of a piece of bar stock, with a leading end and a trailing end, in a substantially straight path between a feeding position and a working position,

the passageway having an upstream end and a downstream end; and

a sensor assembly capable of detecting the position of the trailing end of the piece of bar stock by sensing the trailing end of the piece of bar stock through the upstream end of the passageway with the trailing end of the piece of bar stock within the guide passageway to thereby allow a user to determine if the piece of bar stock in the guide passageway has a length sufficient to perform a desired operation thereon,

wherein the sensor assembly comprises a solid element that can be directed into the passageway to against the trailing end of the piece of bar stock.

2. The lathe assembly according to claim **1** further comprising a spindle for releasably holding the piece of bar stock in the working position.

3. The lathe assembly according to claim **2** wherein the passageway has a center axis and axially spaced first and second ends, the spindle is at the first axially spaced end and the second axially spaced end is open to allow introduction of the piece of bar stock into the guide passageway.

4. The lathe assembly according to claim **1** further comprising a tool assembly to perform an operation on the piece of bar stock in the working position.

5. The lathe assembly according to claim **4** wherein the sensor assembly comprises a generator for a stop signal indicative that the piece of bar stock in the guide passageway has less than a predetermined length and the lathe assembly further comprises a control to receive the stop signal and in response thereto prevent performance of an operation by the tool assembly on the piece of bar stock in the passageway.

6. The lathe assembly according to claim **1** wherein the sensor assembly comprises an elongate element that can be directed into the guide passageway to against the trailing end of the piece of bar stock in the passageway to thereby determine whether the piece of bar stock in the guide passageway is less than or greater than a predetermined length.

7. The lathe assembly according to claim **4** wherein the tool assembly comprises a tool element which acts against the piece of bar stock in the working position and the tool assembly further comprises a turret with a plurality of interchangeable tool elements.

8. The lathe assembly according to claim **1** in combination with the piece of bar stock in the guide passageway.

9. The lathe assembly according to claim **8** wherein the spindle has an axis and axially spaced input and output ends and the piece of bar stock in the working position projects from both the input and output ends of the spindle.

10. The lathe assembly according to claim **1** further comprising a drive to rotate the piece of bar stock in the working position in the guide passageway.

11. A lathe assembly comprising:

a guide having a passageway for movement of a piece of bar stock, with a leading end and a trailing end, in a substantially straight path between a feeding position and a working position,

the passageway having an upstream end and a downstream end; and

a sensor assembly capable of detecting the position of the trailing end of the piece of bar stock by sensing the

trailing end of the piece of bar stock through the upstream end of the passageway with the trailing end of the piece of bar stock within the guide passageway to thereby allow a user to determine if the piece of bar stock in the guide passageway has a length sufficient to perform a desired operation thereon,

wherein the sensor assembly comprises a generator for a beam capable of being directed at the trailing end of the piece of bar stock within the guide passageway.

12. The lathe assembly according to claim **11** wherein the sensor assembly comprises a generator for a signal indicative that the piece of bar stock in the guide passageway has less than a predetermined length.

13. The lathe assembly according to claim **11** wherein the beam directed against the trailing end of the piece of bar stock in the guide passageway is reflected and the sensor assembly further comprises and a receiver for the reflected beam.

14. The lathe assembly according to claim **11** wherein the generator is a laser beam generator.

15. A method of operating a lathe assembly comprising a guide having a passageway with a central axis and axially spaced first and second ends, a spindle, and a tool assembly for performing an operation on a piece of bar stock having a length and leading and trailing ends, said method comprising the steps of:

directing the piece of bar stock axially into the first end of the passageway, and through the guide passageway in a first direction from a feeding position into a working position; and

directing a beam through the first end of the passageway into the guide passageway to sense the trailing end of the piece of bar stock and thereby detect the position of the trailing end of the piece of bar stock and determine if the piece of bar stock in the guide passageway is less than or greater than a predetermined length.

16. A method of operating a lathe assembly comprising a guide having a passageway with a central axis and axially spaced first and second ends, a spindle, and a tool assembly for performing an operation on a piece of bar stock having a length and leading and trailing ends, said method comprising the steps of:

directing the piece of bar stock axially into the first end of the passageway, and through the guide passageway in a first direction from a feeding position into a working position; and

directing a solid element through the first end of the passageway into the guide passageway to sense the trailing end of the piece of bar stock and thereby detect the position of the trailing end of the piece of bar stock and thereby determine if the piece of bar stock in the guide passageway is less than or greater than a predetermined length.

17. The method of operating a lathe assembly according to claim **16** further comprising the step of performing an operation on the piece of bar stock with the tool assembly if it is determined that the piece of bar stock has at least the predetermined length.

18. The method of operating a lathe assembly according to claim **17** including the step of advancing the piece of bar stock in the first direction after performing the operation and again directing the element into the guide passageway to detect the position of the trailing end of the piece of bar stock to again determine if the piece of bar stock in the guide passageway is less than or greater than the predetermined length.

19. The method of operating a lathe assembly according to claim **16** wherein the beam comprises a laser beam.

20. The method of operating a lathe assembly according to claim **16** wherein the step of directing an element into the guide passageway comprises the step of directing an elongate element into the guide passageway.

21. The method of operating a lathe assembly according to claim **16** further comprising the steps of providing a sensor assembly, generating a stop signal from the sensor assembly indicative that the piece of bar stock has a length less than the predetermined length, and processing the stop signal so that no operation is performed by the tool assembly on the piece of bar stock in the guide passageway.

* * * * *

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(12) **United States Patent**
Miyano

(10) **Patent No.:** **US 6,553,875 B1**
(45) **Date of Patent:** **Apr. 29, 2003**

(54) **MACHINE TOOL ASSEMBLY**

(76) Inventor: **Toshiharu (Tom) Miyano**, 50 Dundee La., Barrington Hills, IL (US) 60010

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 148 days.

(21) Appl. No.: **09/633,545**

(22) Filed: **Aug. 7, 2000**

(51) **Int. Cl.**[7] **B23B 7/00**; B23B 9/00

(52) **U.S. Cl.** **82/117**; 82/128; 82/129; 82/149

(58) **Field of Search** 82/117, 113, 128, 82/130, 131, 132, 149, 129, 107, 112, 114, 115, 116, 138, 142, 173

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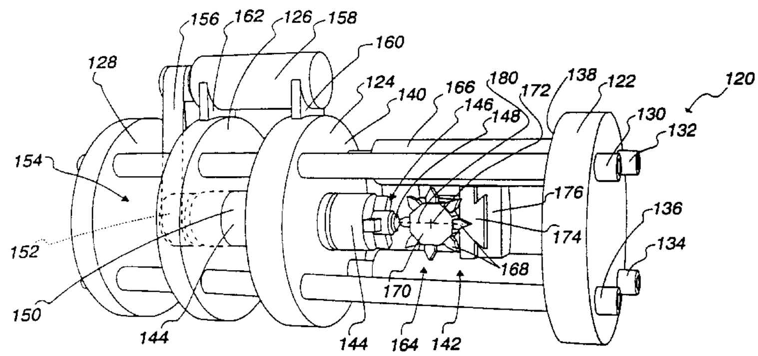
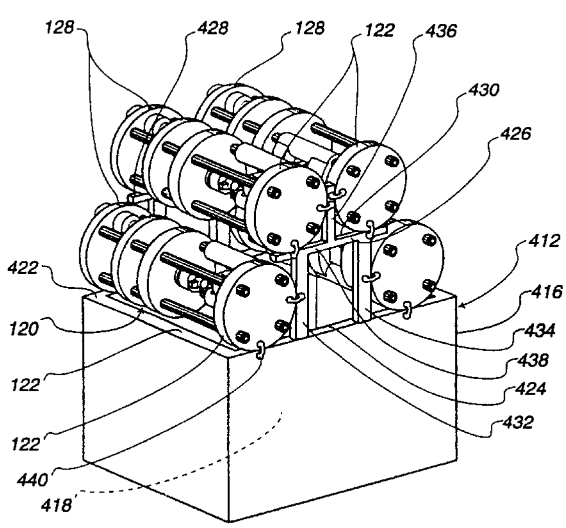
Primary Examiner—Henry W. H. Tsai
(74) *Attorney, Agent, or Firm*—Wood, Phillips, Katz, Clark & Mortimer

(57) **ABSTRACT**

A machine tool assembly having a frame, a workpiece holder, and at least one machining unit that is operable to perform an operation on a workpiece in an operative position on the workpiece holder. The frame has first and second spaced end supports and at least one reinforcing element which extends between the first and second end supports so as to maintain the first and second end supports in a desired operative relationship. The workpiece holder and at least one machining unit each are connected to at least one of the first and second end supports and at least one reinforcing element so that the machining unit can be operated to perform an operation on a workpiece in an operative position on the workpiece holder.

53 Claims, 17 Drawing Sheets





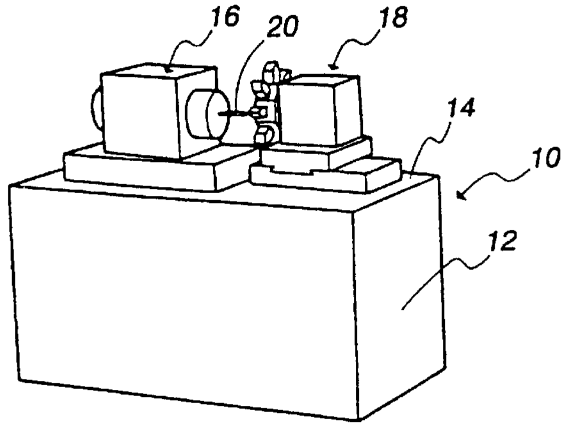


Fig.1
(Prior Art)

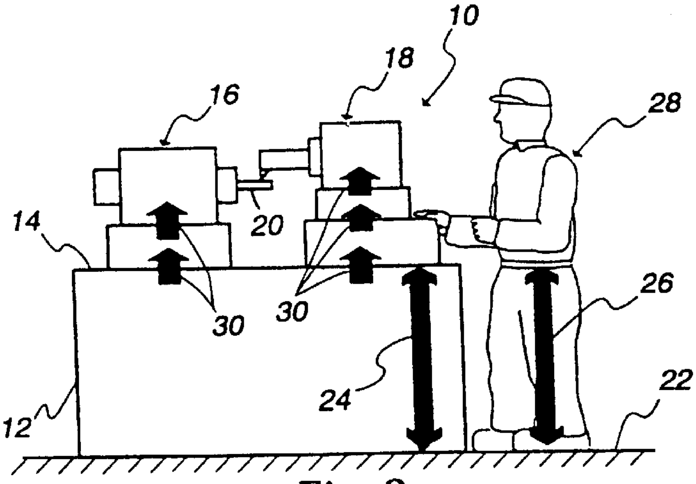


Fig. 2
(Prior Art)

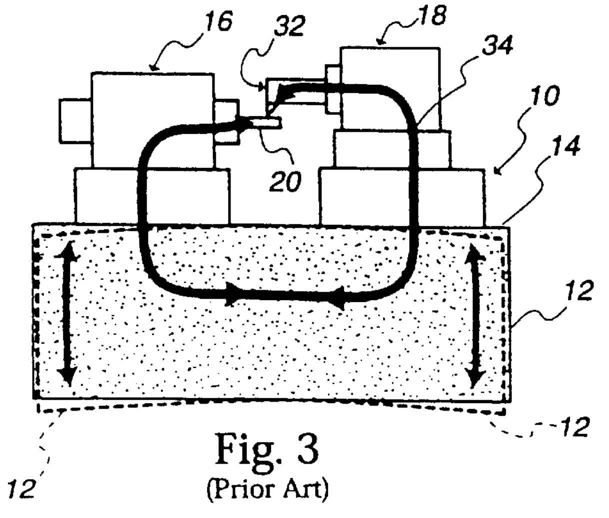


Fig. 3
(Prior Art)

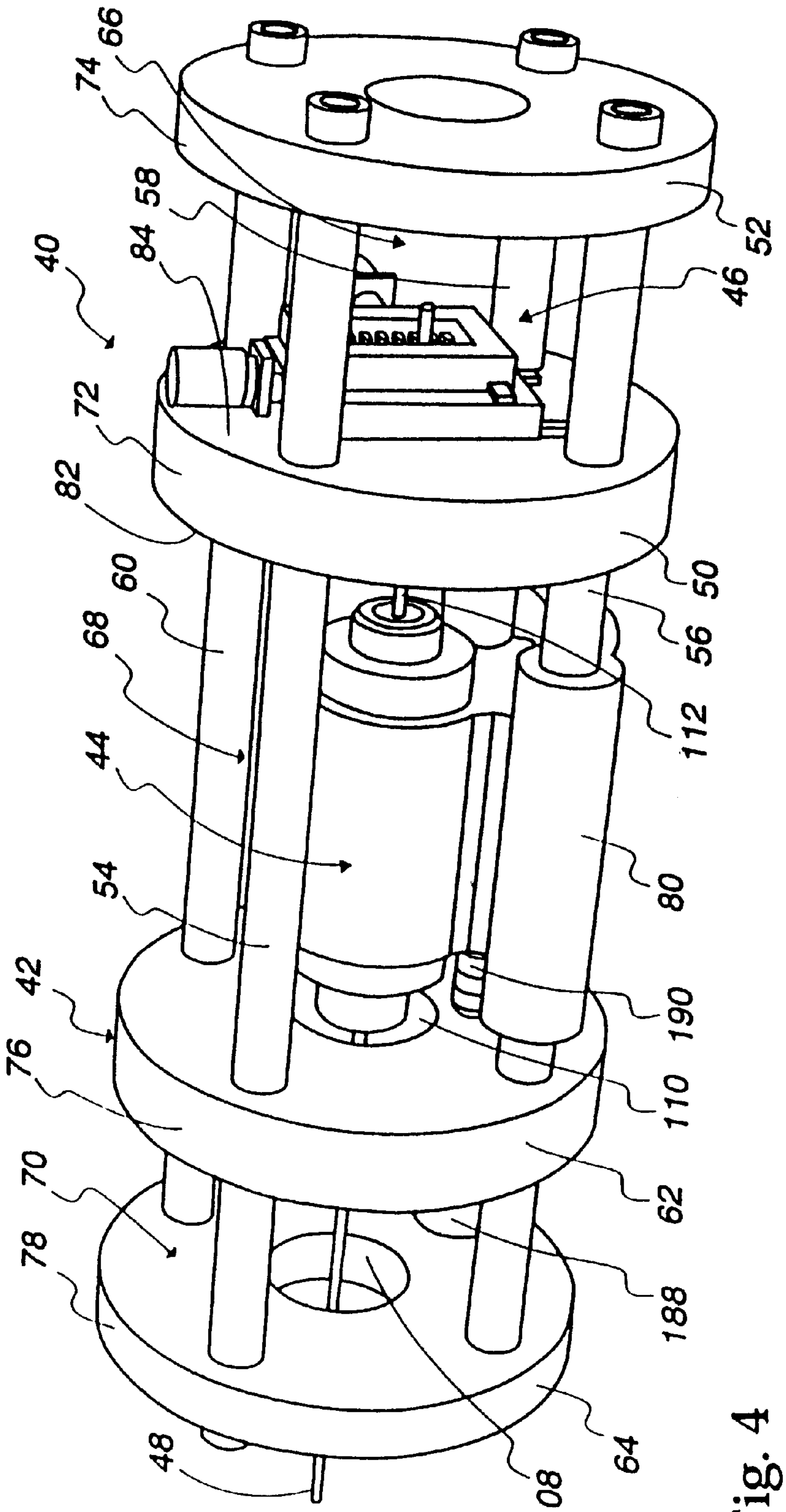

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Fig. 4

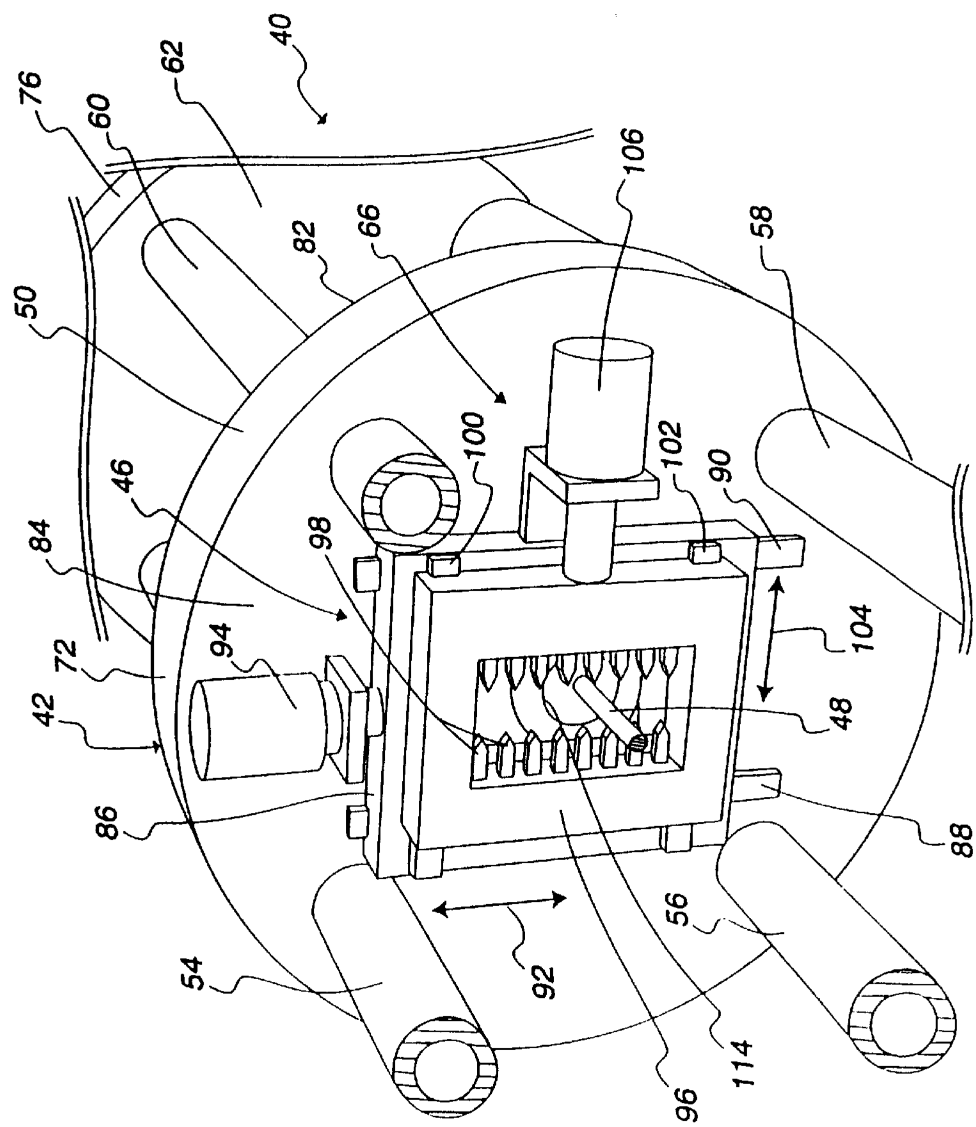
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Fig. 5

Fig. 6

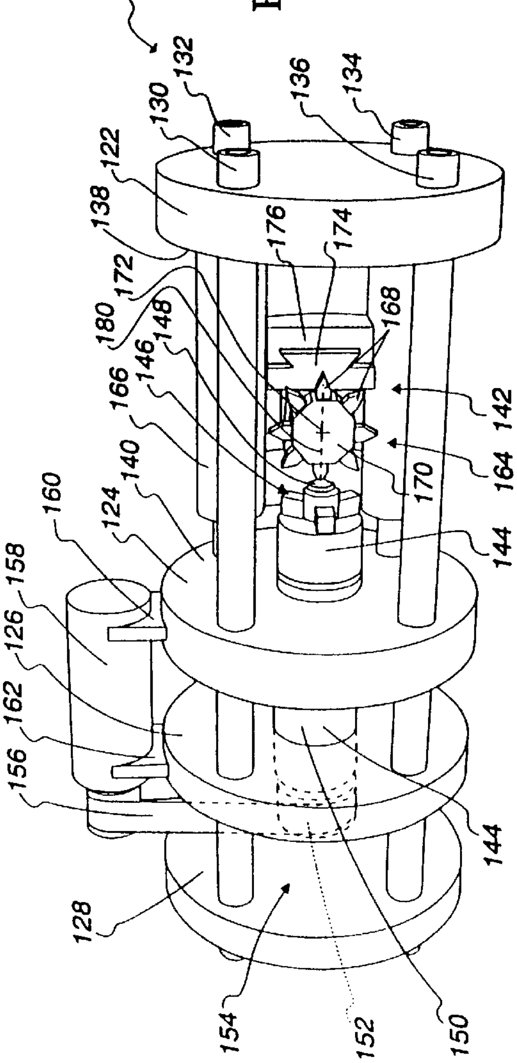
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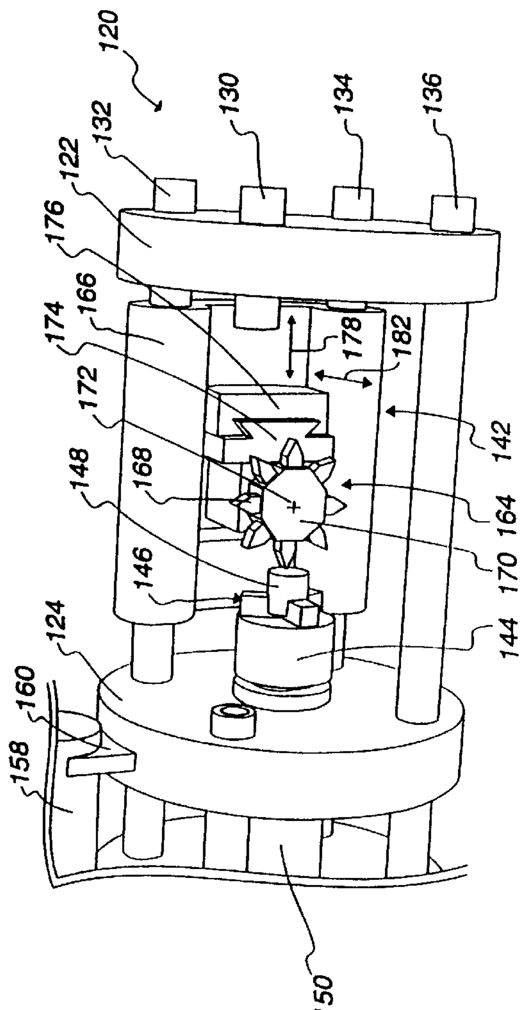
Fig. 7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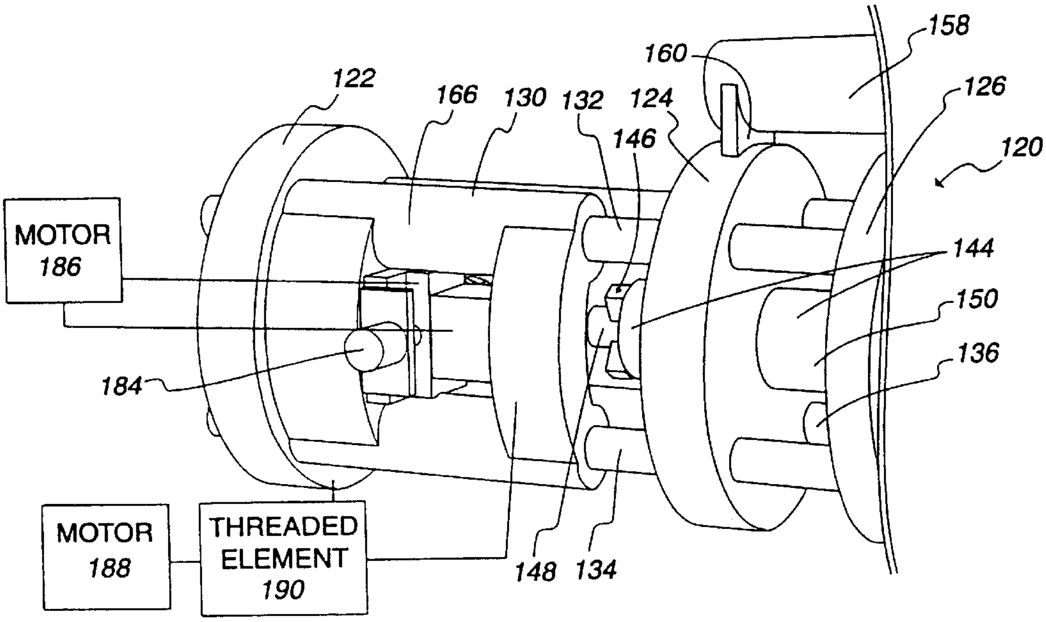
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Fig. 8

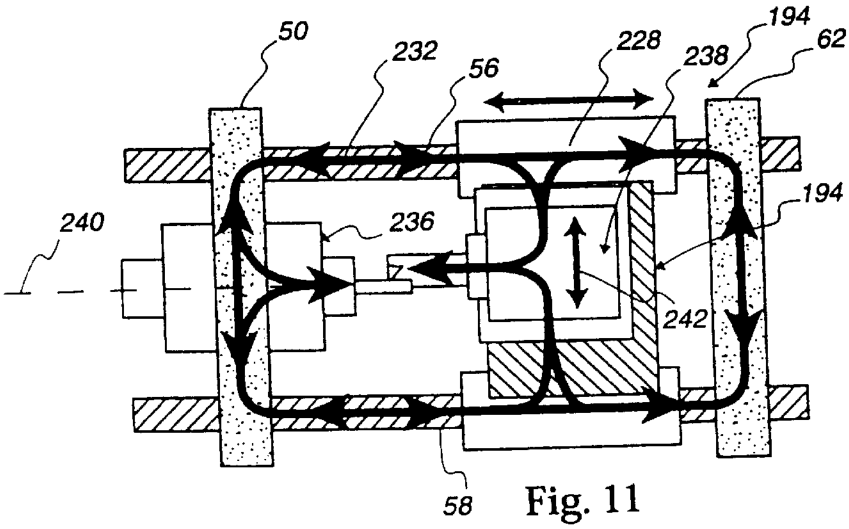
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Fig. 11

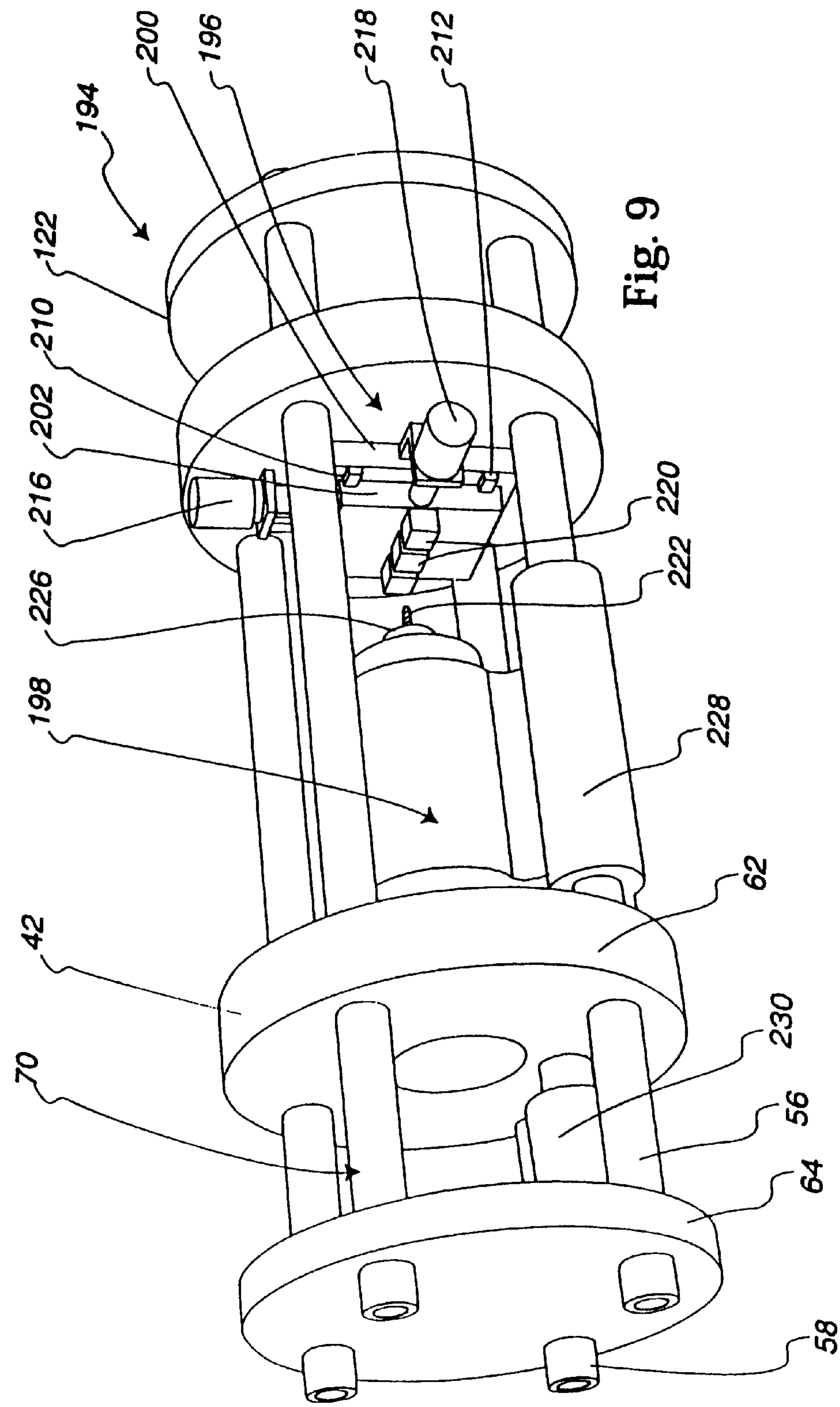
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Fig. 9

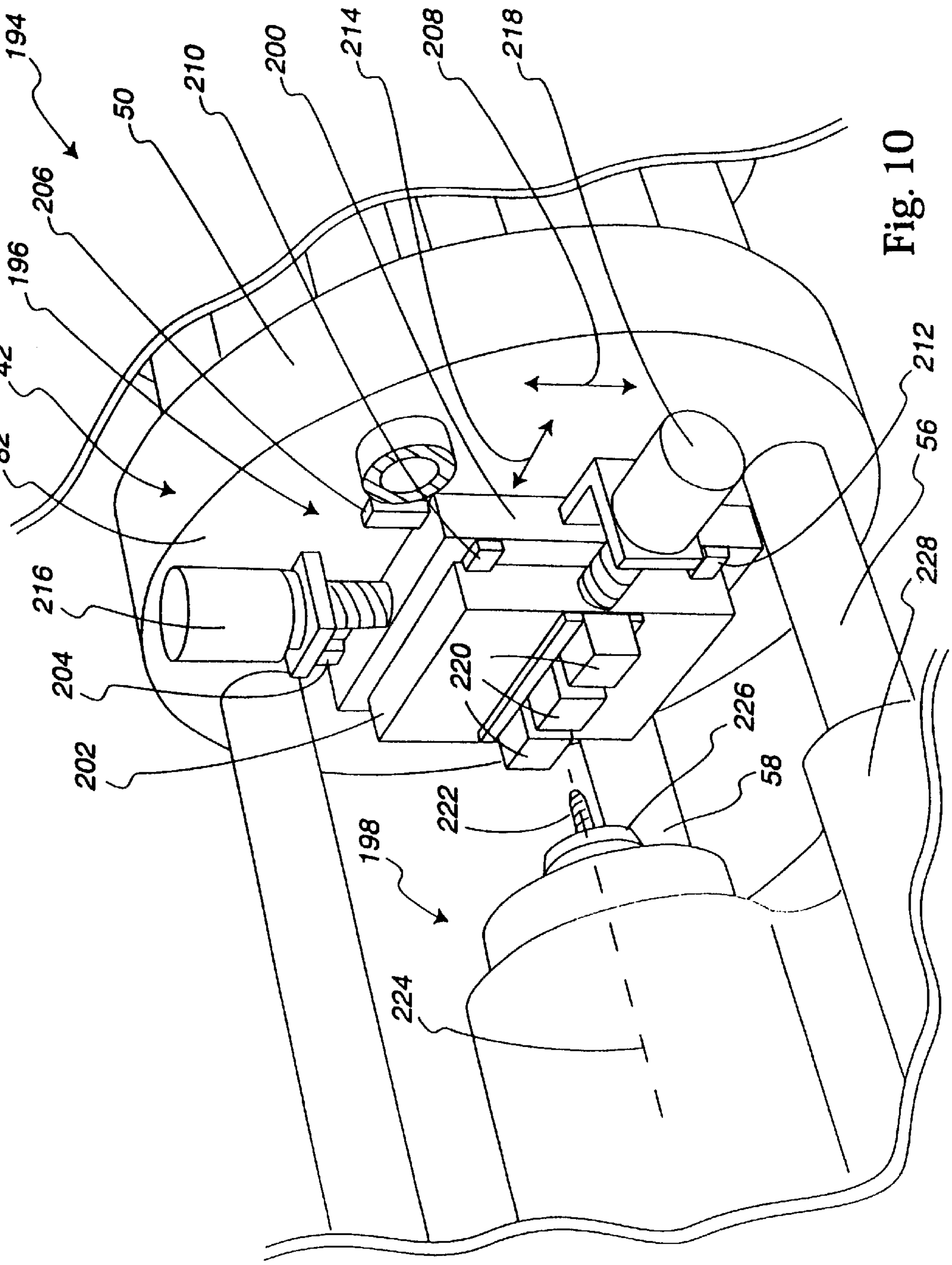
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Fig. 10

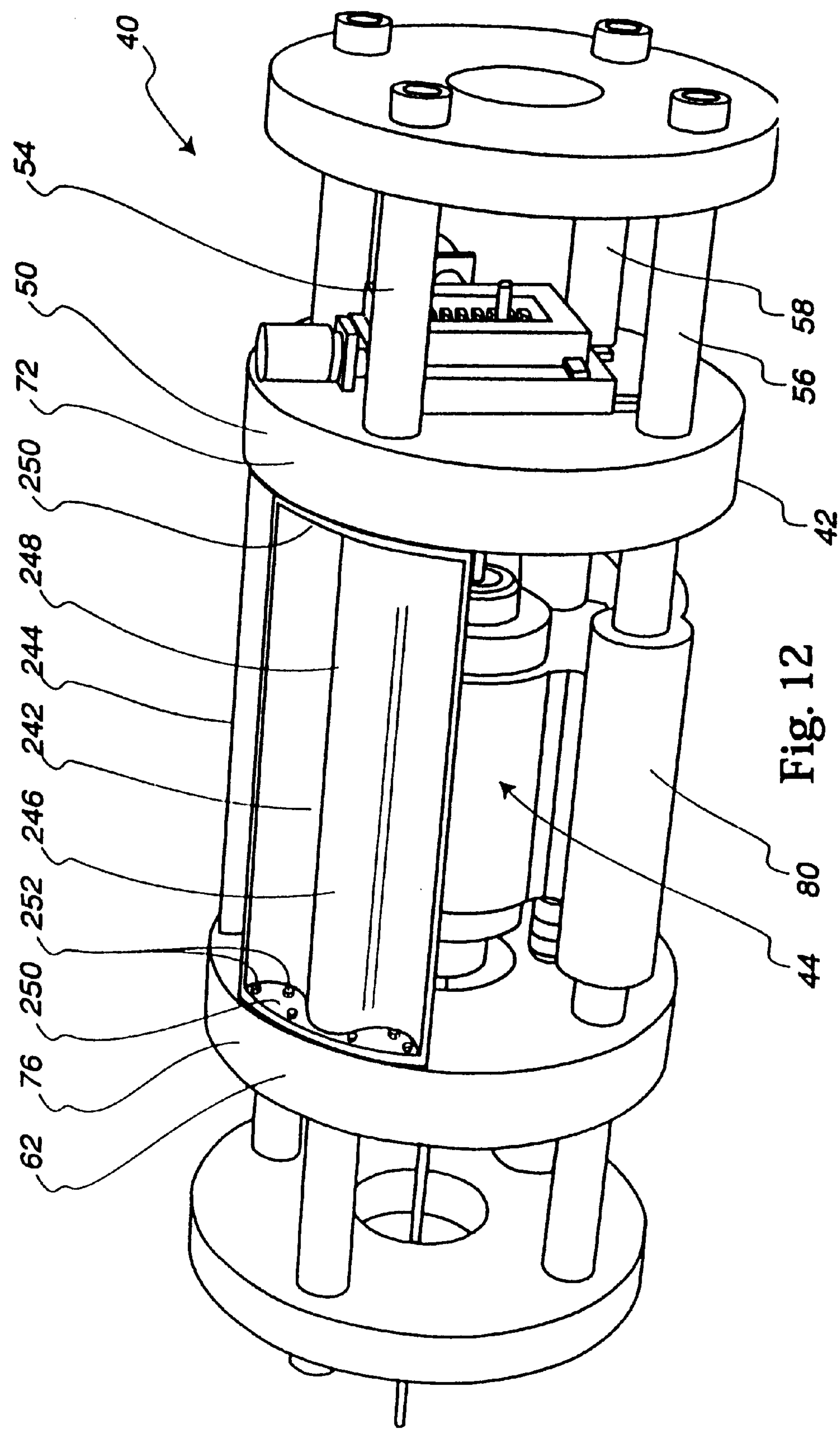


Fig. 12

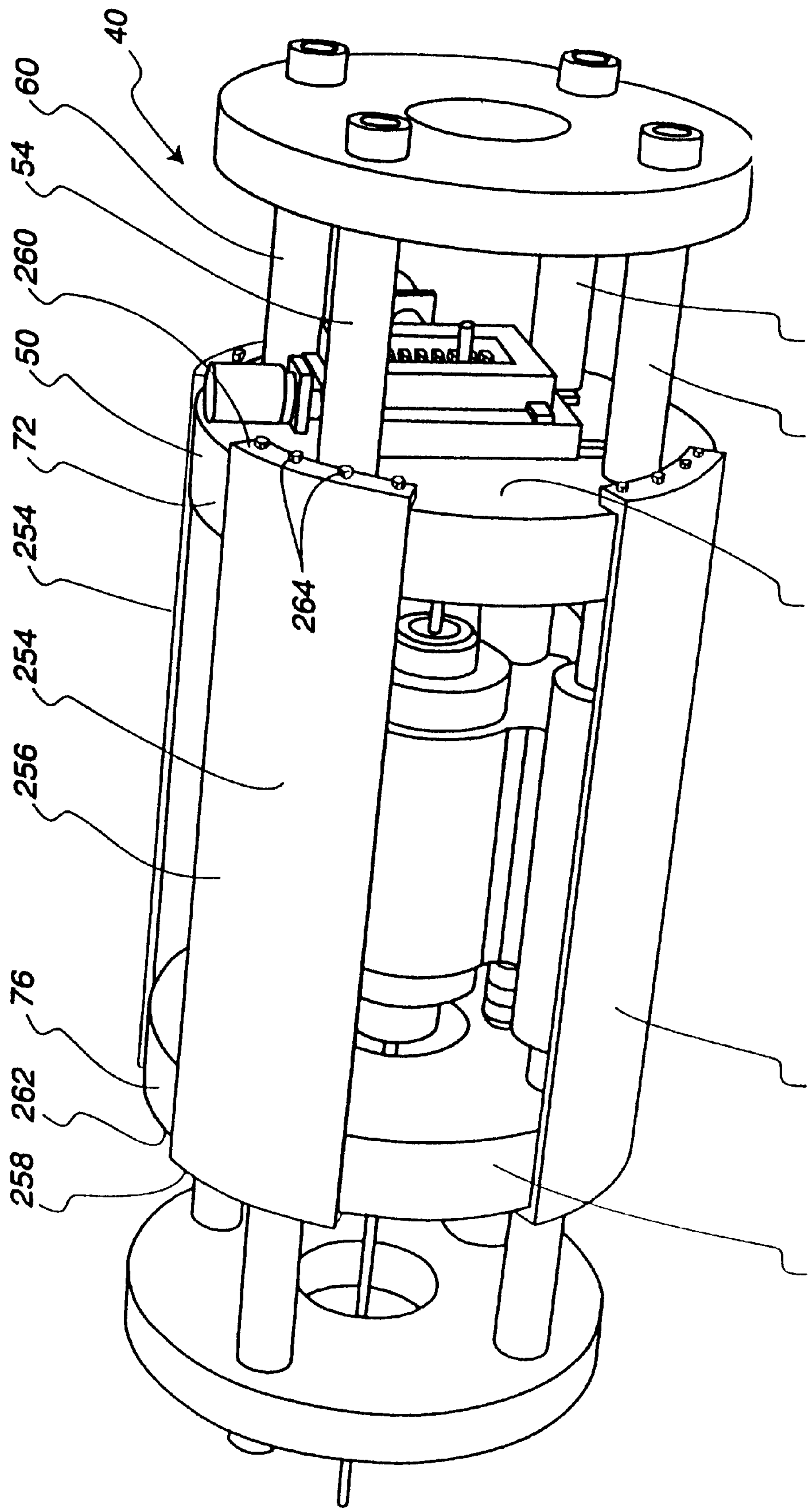


Fig. 13

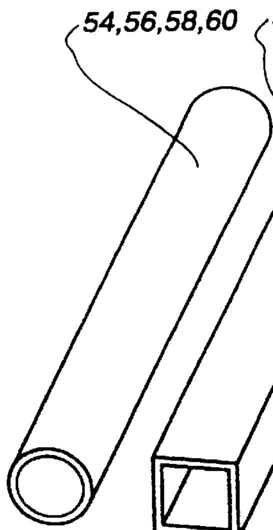


Fig. 14

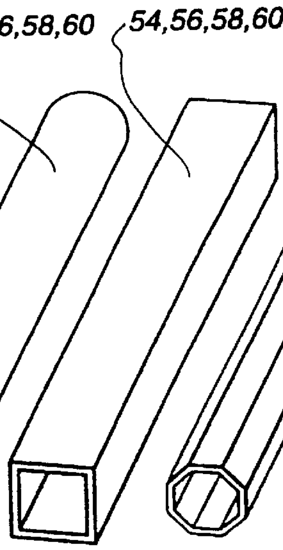


Fig. 15

Fig. 16

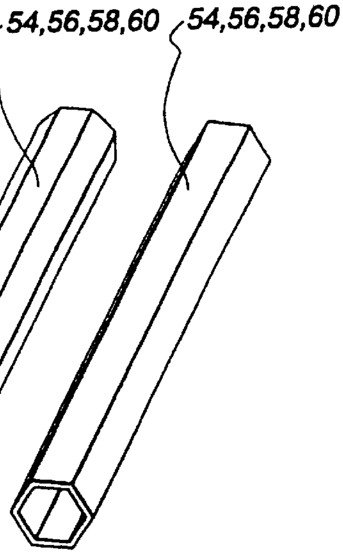
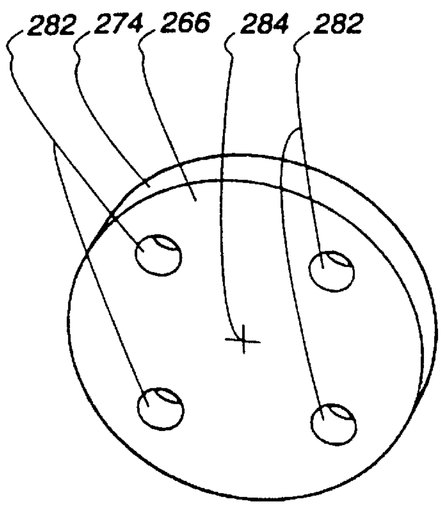


Fig. 17



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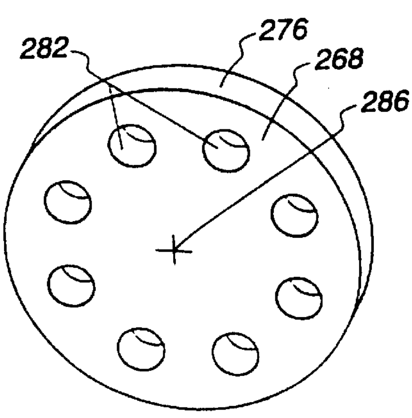


Fig. 19

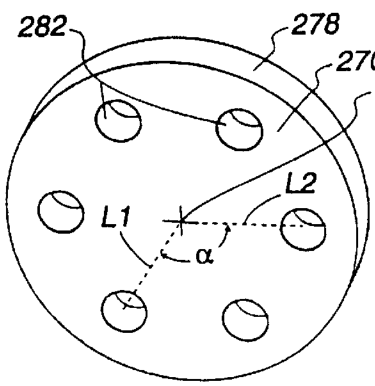


Fig. 20

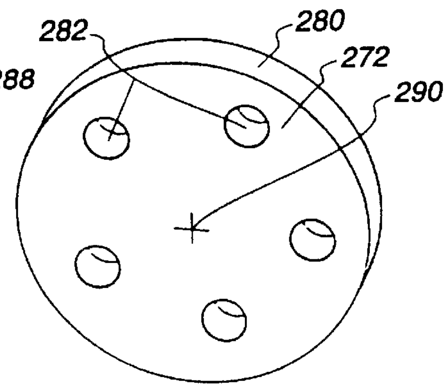
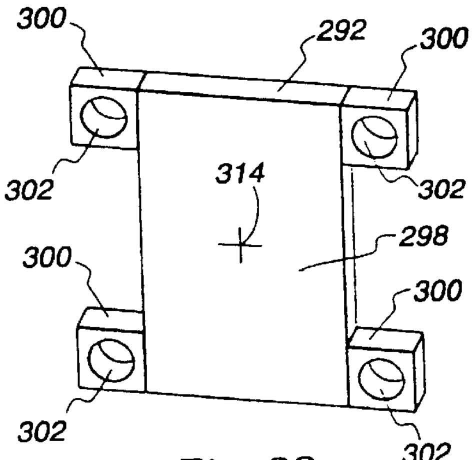


Fig. 21



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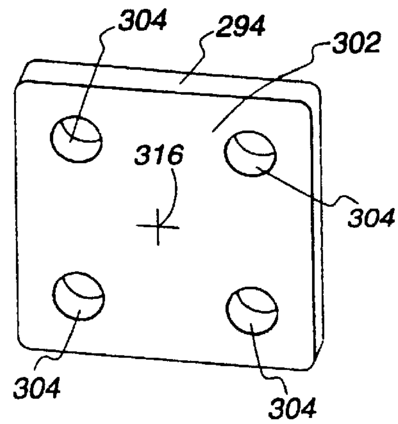
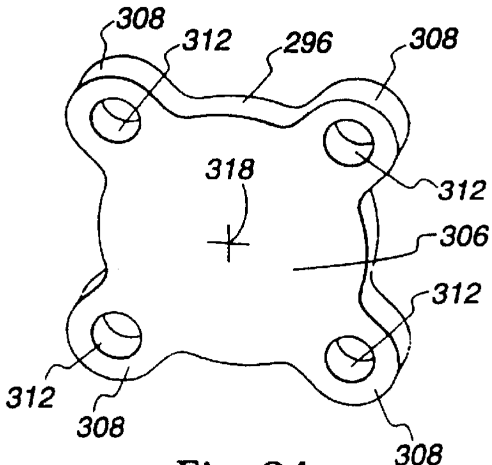


Fig. 23



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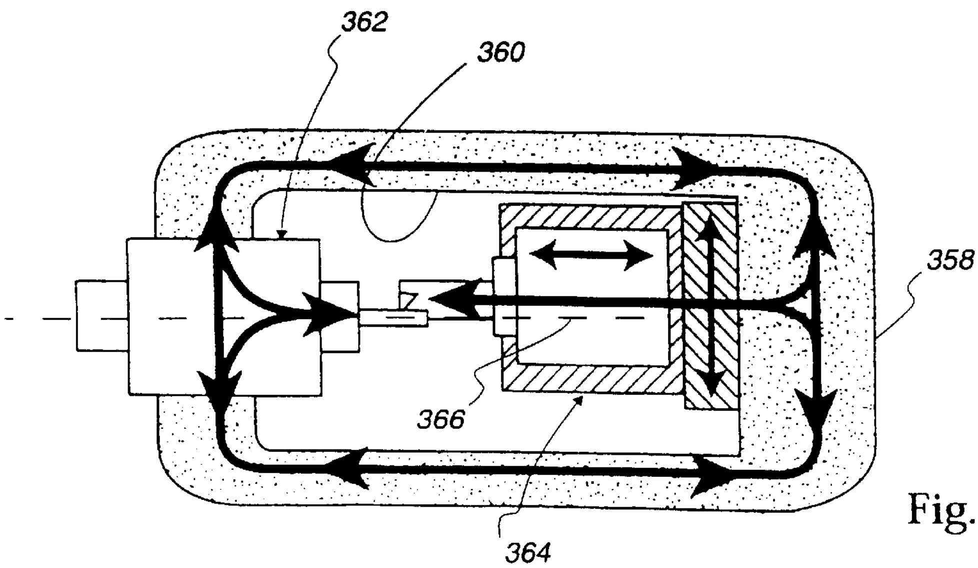

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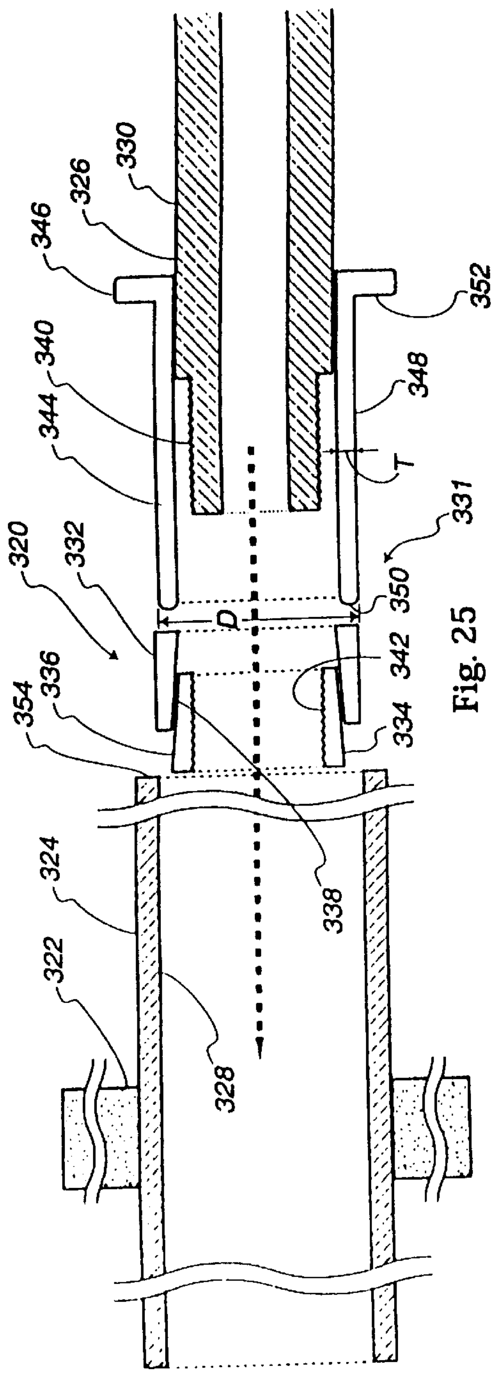
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Fig. 25

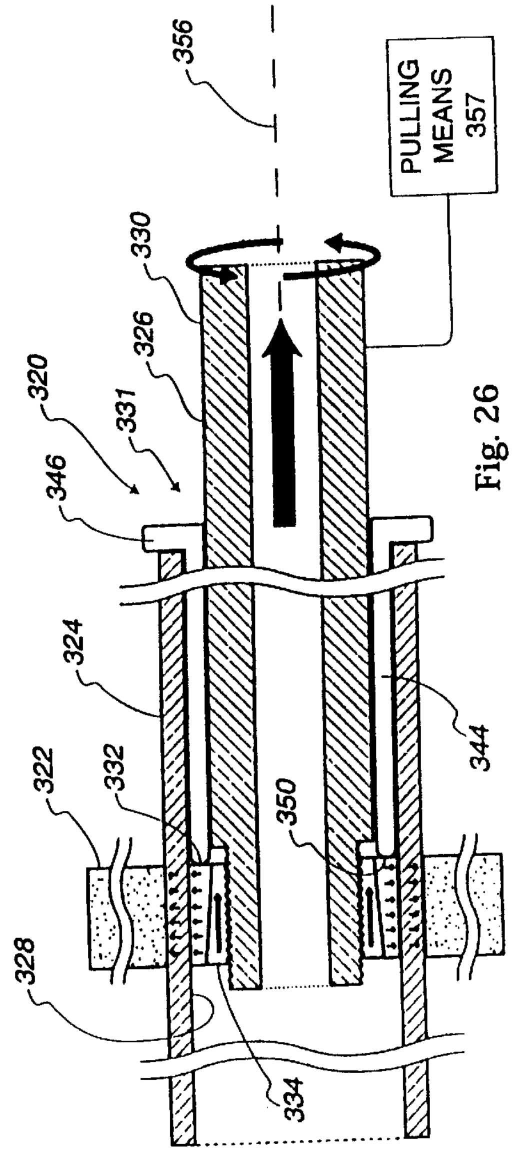
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Fig. 26

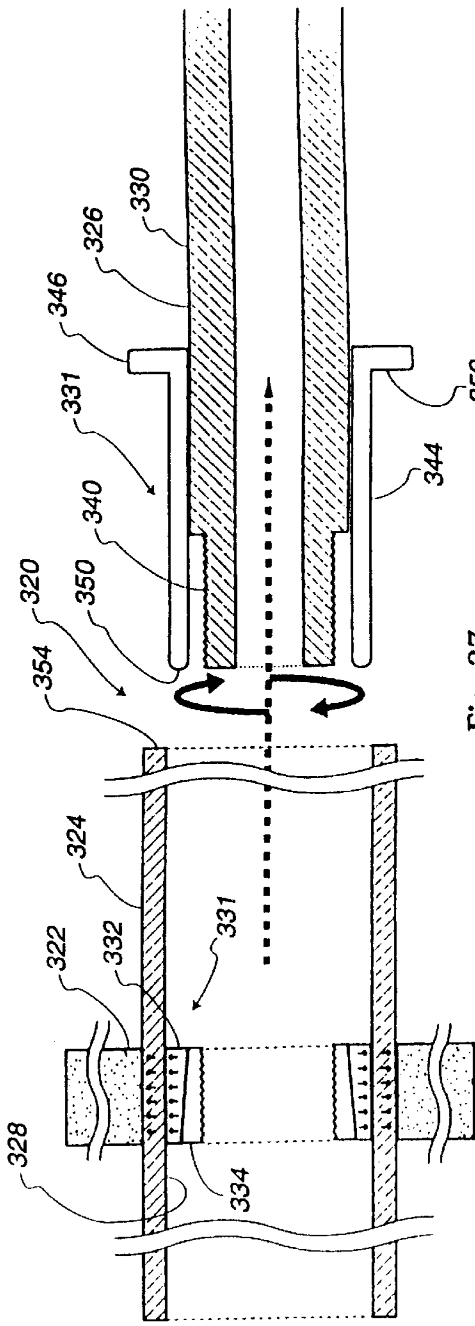
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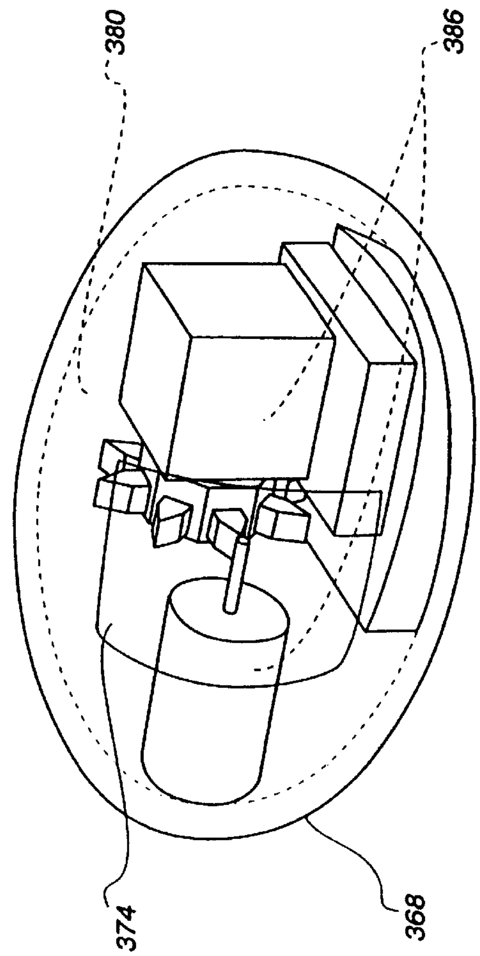
Fig. 27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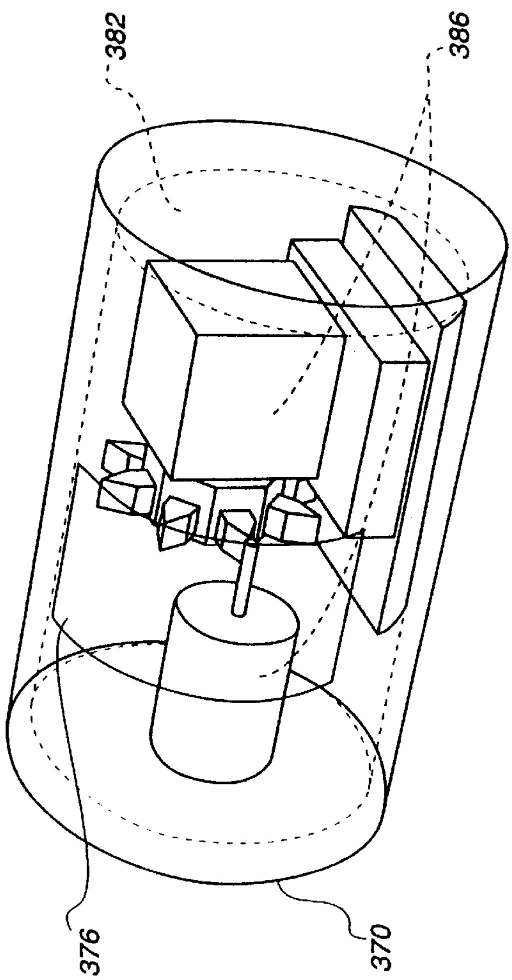
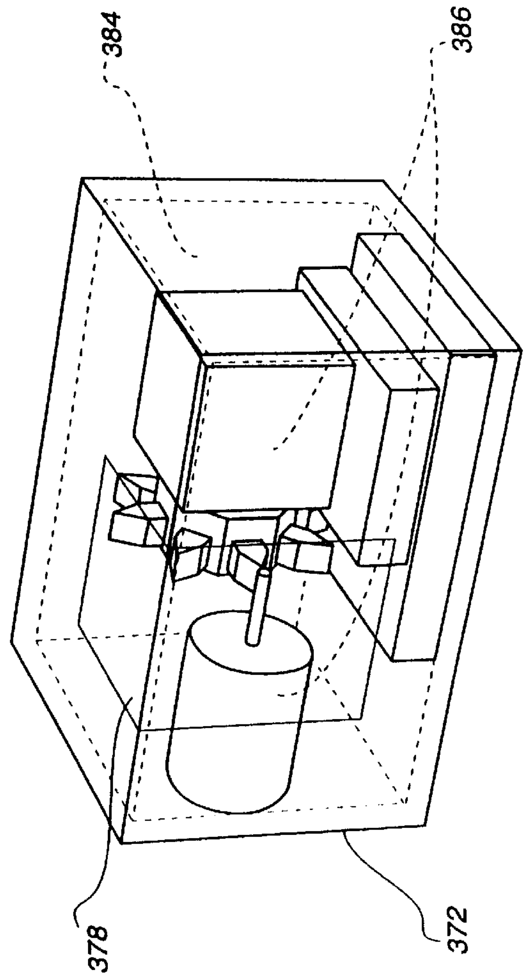


Fig. 30



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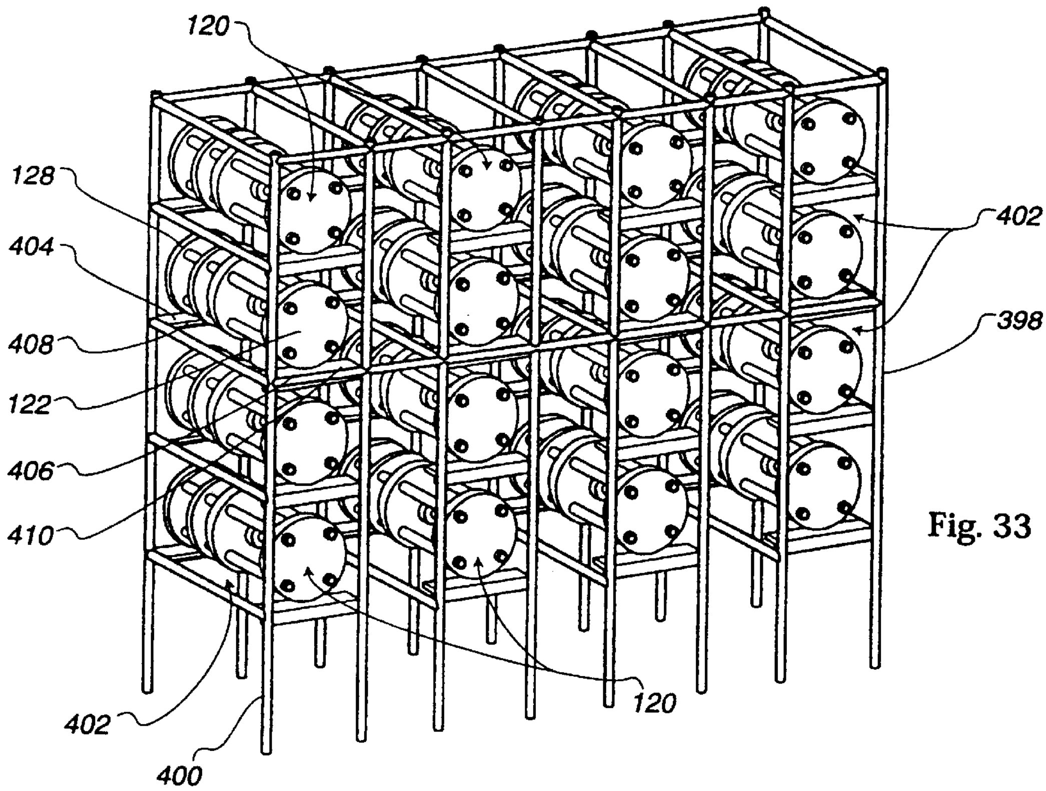
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Fig. 33

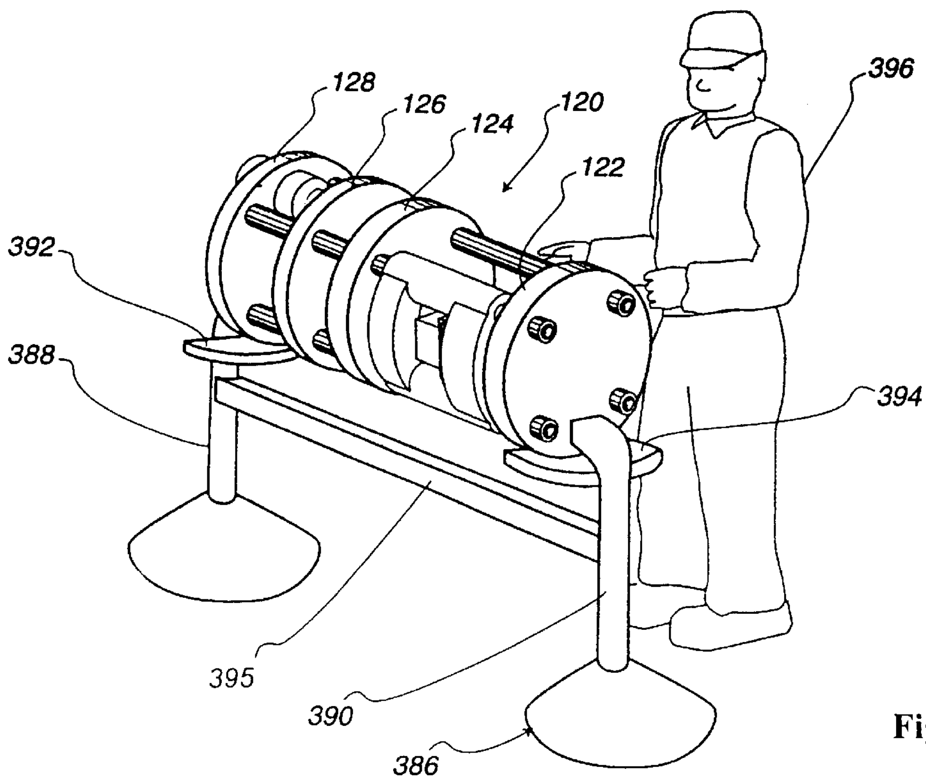
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Fig. 32

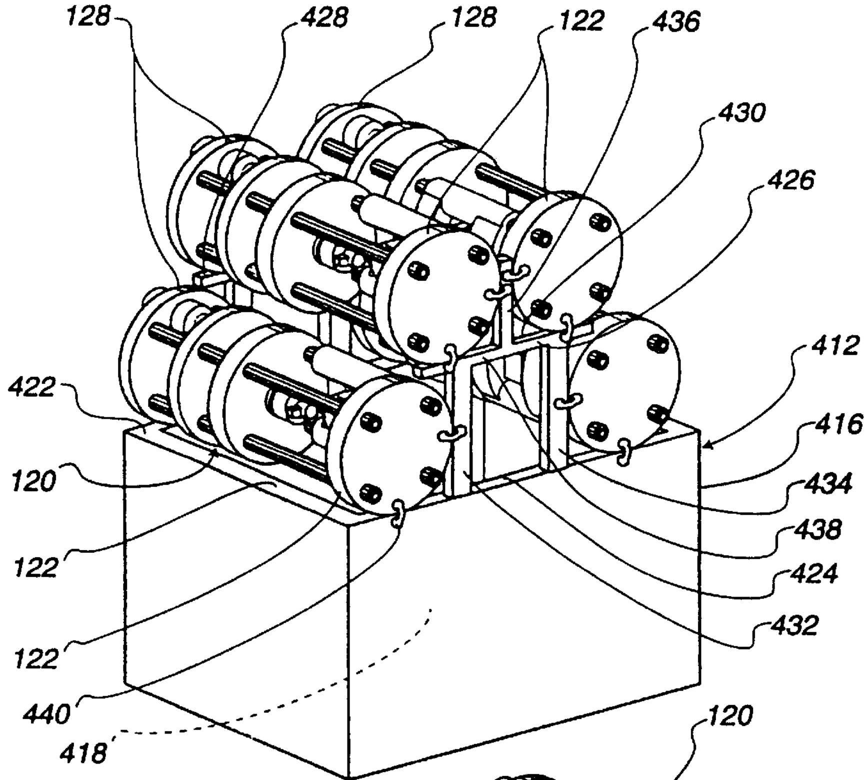

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Fig. 34

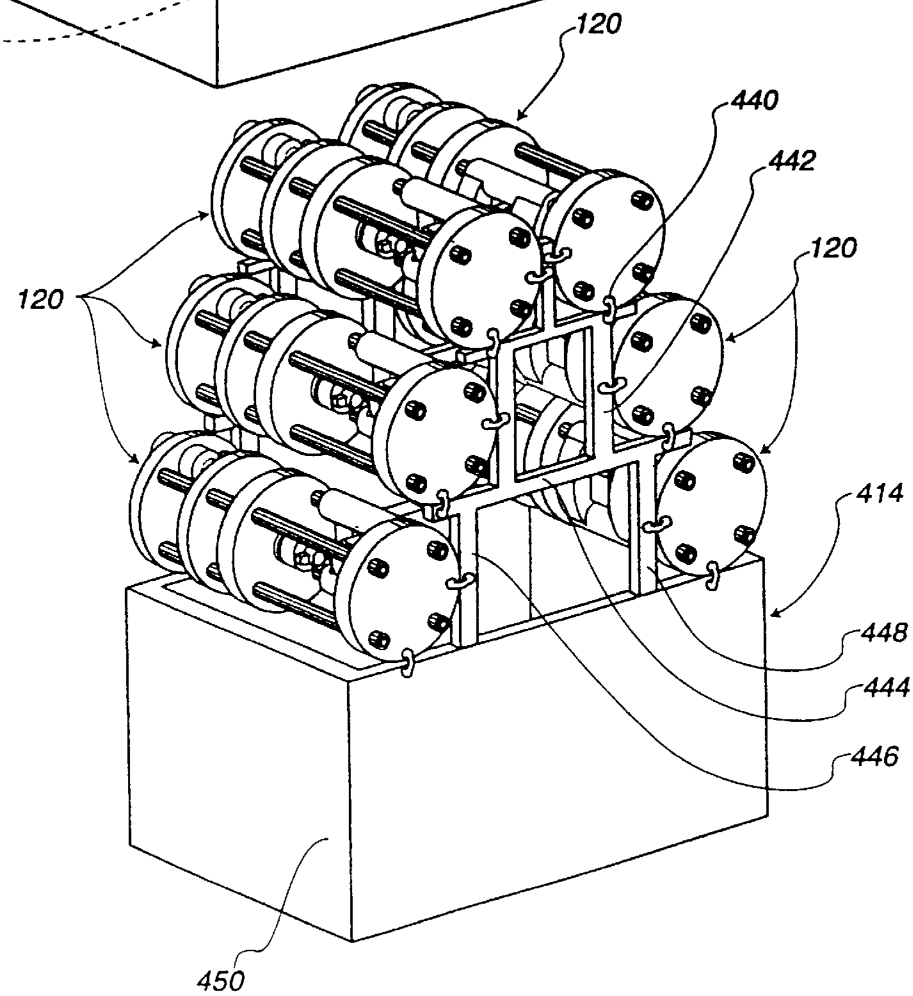

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Fig. 35

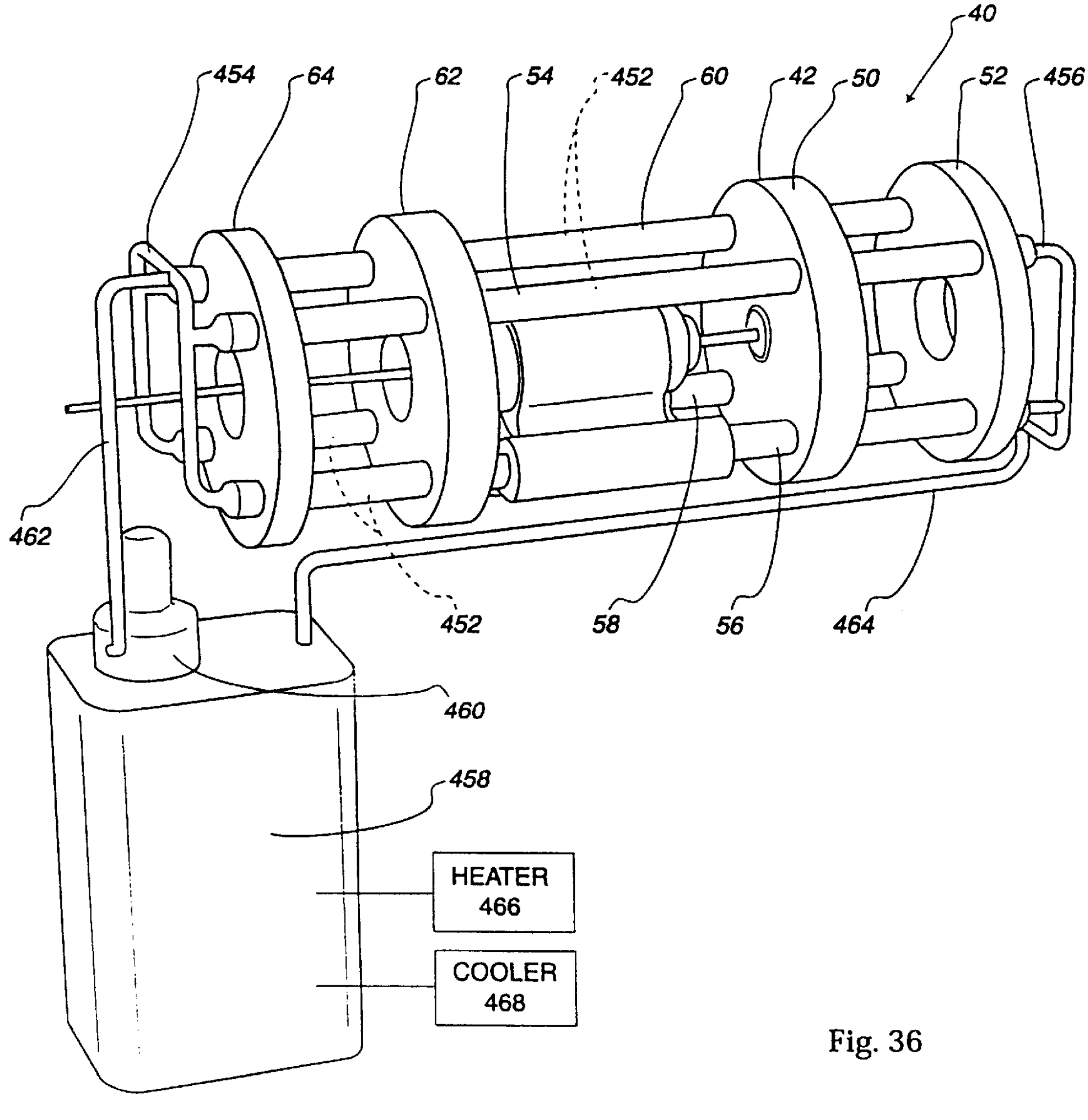
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Fig. 36

MACHINE TOOL ASSEMBLY

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to machine tools and, more particularly, to a machine tool assembly that can be operated with the machine tool assembly in different orientations.

2. Background Art

Designers of machine tools attempt to achieve a number of different goals. First of all, accuracy is of utmost importance in the design of any machine tool. At the same time, it is desirable to make machine tools to have a relatively compact construction.

A conventional machine tool construction is shown in FIGS. **1–3** herein at **10**. The machine tool **10** consists of a base **12** with an upper surface **14** supporting machine tool components, in this case a workpiece holder **16** and a machining unit **18**, for performing a machining operation on a workpiece **20** on the workpiece holder **16**.

In designing the base **12** forthe machine tool components **16,18**, there are a number of considerations. First of all, the height of the upper surface **14** above the subjacent surface **22**, as indicated by the double-headed arrow **24**, is generally selected to match the waist height for an operator **28**, as indicated by the double-headed arrow **26**. Consequently, the base **12**, by reason of this height requirement, has a substantial mass. Since the base **12** is commonly constructed from a heat conductive material, the larger the mass, the more heat retention there is during operations and the more the base becomes prone to thermally induced deformation. The potential deflection of spaced ends of the base **12**, due to heating, is shown schematically in FIG. **3**, as indicated by the dotted lines **12**. Any base deformation potentially causes a misalignment of the cooperating workpiece holder **16** and machining unit **18**, which may detract from the accuracy of any machining operation.

This conventional type of machine tool **10** is normally constructed by building the components thereof in a pyramidal-type fashion for stability. That is, inherently the overall stability of the machine tool **10** is established and maintained by stacking components, as indicated by the arrows **30**, like building blocks of decreasing mass, from bottom to top. This construction is desired for stability in this type of system and is classified as an open loop system.

As seen in FIG. **3**, an open loop system is one wherein the operating components and the base are not structurally contiguous. In FIG. **3**, it can be seen that the machining unit **18** has a cantilevered working end **32** which operates on the workpiece **20** which is cantilever supported from the workpiece holder **16**. Thus, the structural loop, as indicated by the arrows **34**, is interrupted between the machining unit **18** and the workpiece holder **16**. Consequently, any deformation of the base **12** may cause a relative repositioning of the workpiece holder **16** and machining unit **18** so as to potentially detract from the accuracy of any machining operation. Similarly, any movement of the workpiece holder **16** and machining unit **18** relative to each other and the base **12** may have the same consequences.

SUMMARY OF THE INVENTION

In one form, the invention is directed to a machine tool assembly having a frame, a workpiece holder, and at least one machining unit that is operable to perform an operation on a workpiece in an operative position on the workpiece

holder. The frame has first and second spaced end supports and at least one reinforcing element which extends between the first and second end supports so as to maintain the first and second end supports in a desired operative relationship. The workpiece holder and at least one machining unit each are connected to at least one of the first and second end supports and at least one reinforcing element so that the machining unit can be operated to perform an operation on a workpiece in an operative position on the workpiece holder.

In one form, the first and second end supports have the form of a disk-shaped element, with the at least one reinforcing element having the shape of a first elongate bar.

The elongate bar may extend through at least one of the first and second end supports.

The frame may further include a second elongate bar, with each of the first and second elongate bars having a length, with the lengths of the first and second elongate bars being substantially parallel.

The frame may further include a third elongate bar.

The frame may further include a third disk-shaped element which is connected to the first elongate bar.

The at least one reinforcing element may be in the form of a first elongate plate.

The frame may include a second elongate plate which connects to the first and second end supports.

The first elongate bar may include first and second joinable parts.

The first and second joinable parts may be extendable, one within the other.

In one form, the first joinable part has an annular inside surface and the second joinable part has an annular outside surface with the at least one reinforcing element including a wedge assembly with a first wedge element between the annular inside surface of the first joinable part and the annular outside surface of the second joinable part.

The wedge assembly may further include a second wedge element between the annular inside surface of the first joinable part and the annular outside surface of the second joinable part.

The first and second wedge elements may act directly against each other.

The second wedge element may be threadably engaged with the second joinable part.

The wedge assembly may further include a wedge repositioning element which can be directed into the first joinable part to reposition at least one of the first and second wedge elements.

In one form, the first joinable part has an end and the wedge repositioning element has a shoulder which is abuttable to the end of the first joinable part to limit movement of the wedge repositioning element into the first joinable part.

The first elongate bar may have a through passageway.

A temperature controlling fluid may be directed through the passageway of the first elongate bar.

In one form, the first elongate bar has a cross-sectional configuration taken transversely to its length which is substantially circular.

This cross-sectional configuration may be non-circular or polygonal.

In one form, the first and second end supports each include a disk-shaped element with a perimeter edge defining substantially a circular shape.

The perimeter edges of the end supports may define a square shape.

In one form, the perimeter edges have spaced projections which may be bridged by a support upon which the machine tool assembly is placed.

The shape of the peripheral edges of the first and second end supports may be substantially the same.

In one form, the first and second end supports and at least one reinforcing element cooperatively define a caged working space within which a machining operation may be performed by the at least one machining unit.

In one form, the first and second end supports have first and second facing surfaces which bound a working space and the at least one machining unit is mounted on the first facing surface.

In one form, the first end support has oppositely facing first and second surfaces on the first and second opposite sides of the first end support and the workpiece holder is on the first side of the first end support and the at least one machining unit is on the second side of the first end support.

The first end support may have an opening through which a workpiece held by the workpiece holder can be directed to be operated upon by the at least one machining unit.

In one form, the frame, workpiece holder, and at least one machining unit define a machine tool module that can be operated in any orientation.

In one form, the frame defines a passageway for guiding movement of a temperature controlling fluid.

In one form, the at least one reinforcing element has a first elongate hollow bar, the frame has a second elongate hollow bar extending between the first and second end supports, and a passageway for temperature controlling fluid is defined through the first and second elongate hollow bars.

The passageway may be continuous to permit circulation of a temperature controlling fluid.

A pump may be provided for circulating temperature controlling fluid in the passageway.

The machine tool assembly may further include a temperature controlling fluid in the passageway.

The invention is also directed to the combination of a base and a first machine tool assembly that can be placed in an operative position on the base in an elevated position over a subjacent support surface, with the machine tool assembly having the configuration as described above.

The combination may further include a second machine tool assembly substantially the same as the first machine tool assembly that can be placed in an operative position on the base and in an elevated position over a subjacent support surface so that machining operations can be performed simultaneously by the first and second machine tool assemblies.

The base may define a reservoir for collection of workpiece particles and machining fluids generated during machining operations.

The base may have stepped surfaces for the first and second machine tool assemblies.

The end supports on the first and second machine tool assemblies may be supported directly against the base.

In one form, the at least one reinforcing element on the first and second machine tool assemblies does not directly engage the base.

The end supports on the first and second machine tool assemblies may each have a perimeter surface that is substantially circular.

Connectors may be provided for joining between the base and at least one of the end supports on each of the first and second machine tool assemblies to maintain the first and second machine tool assemblies in the operative position on the base.

The base may include a frame defining a plurality of compartments each configured to receive a machine tool assembly substantially the same as the first machine tool assembly.

The invention is further directed to a machine tool assembly having a frame, a workpiece holder, and at least one machining unit that is operable to perform an operation on a workpiece in an operative position on the workpiece holder. The frame defines a cage with an external surface which permits different portions of the external surface of the machine tool assembly module to be placed against a support surface to permit performance of a machining operation with the machine tool assembly module in different orientations.

In one form, the frame has a lengthwise axis and the external surface of the frame is configured to extend substantially fully around the lengthwise axis.

The frame may include first and second end supports and at least one reinforcing element which extends between the first and second end supports so as to maintain the first and second end supports in a desired operative relationship.

In one form, the frame has a central lengthwise axis and further includes a second reinforcing element which extends between the first and second end supports. First and second lines extending from the central axis to the first and second reinforcing elements define an included angle of at least 90°. In one form, this included angle is 120°.

In one form, the frame has a central lengthwise axis and includes a second reinforcing element which extends between the first and second end supports, with the first and second end supports each including an elongate bar, with the first and second elongate bars being diametrically oppositely situated relative to the elongate central axis.

In one form, the external surface of the cage has a rounded shape. Alternatively, the external surface could have a squared shape, a cylindrical shape, or other shapes.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a conventional machine tool mounted upon a base;

FIG. **2** is a side elevation of the machine tool assembly and base of FIG. **1**;

FIG. **3** is a view as in FIG. **2** and schematically showing deflection of the base that may occur under certain operating conditions;

FIG. **4** is a perspective view of a machine tool assembly, according to the present invention, and consisting of a frame with end supports and reinforcing elements connecting between the end supports;

FIG. **5** is an enlarged, fragmentary, perspective view of one end of the machine tool assembly in FIG. **4**;

FIG. **6** is a view as in FIG. **4** of a modified form of machine tool assembly, according to the present invention;

FIG. **7** is an enlarged, fragmentary, perspective view of the machine tool assembly in FIG. **6** from substantially the same perspective as in FIG. **6**;

FIG. **8** is a fragmentary, perspective view of the machine tool assembly of FIGS. **6** and **7**, taken from the side opposite that in FIGS. **6** and **7**;

FIG. **9** is a perspective view of another modified form of machine tool assembly, according to the present invention;

FIG. **10** is an enlarged, fragmentary, perspective view of machine tool components on one end of the machine tool assembly in FIG. **9**;

FIG. **11** is a schematic plan view of the machine tool assembly of FIGS. **9** and **10**;

FIG. **12** is a perspective view of the machine tool assembly of FIGS. **9** and **10** modified by the use of one form of elongate reinforcing plate;

FIG. **13** is a view as in FIG. **12** showing a modified form of reinforcing plate;

FIGS. **14–17** are perspective views of different configurations for reinforcing elements on the inventive machine tool assemblies;

FIGS. **18–24** are perspective views of different configurations of end supports useable to make a frame for machine tool assemblies according to the present invention;

FIG. **25** is a fragmentary, cross-sectional view showing a two part reinforcing element that can be used to define frames for the inventive machine tool assemblies with first and second parts of the reinforcing elements in a pre-assembly position;

FIG. **26** is a view as in FIG. **25** with the first and second parts in assembled relationship;

FIG. **27** is a view as in FIG. **26** with the first and second parts fully separated from each other;

FIG. **28** is a schematic, plan view of a modified form of machine tool assembly according to the present invention including an encapsulating frame for machine tool assembly components;

FIGS. **29–31** are perspective views of modified forms of encapsulating frames such as that in FIG. **28**;

FIG. **32** is a perspective view of the machine tool assembly in FIGS. **6–8** mounted to one form of base;

FIG. **33** is a perspective view of another form of base used to support a plurality of the inventive machine tool assemblies;

FIG. **34** is a perspective view of another form of base used to support a plurality of the inventive machine tool assemblies;

FIG. **35** is a perspective view of a still further form of base used to support a plurality of the inventive machine tool assemblies; and

FIG. **36** is a perspective view of one of the inventive machine tool assemblies adapted so that cooling fluid can be continuously circulated therethrough.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring initially to FIGS. **4** and **5**, one form of machine tool assembly, according to the present invention; is shown at **40**. The machine tool assembly **40** consists of a frame **42** upon which a workpiece holder **44** and machining unit **46** are mounted. The machining unit **46** is operable to perform an operation on a workpiece **48** in an operative position on the workpiece holder **44**.

As used herein, "workpiece holder" is intended to identify that structure which physically holds a workpiece during the performance of a machining operation. The workpiece holder may maintain the workpiece in a stationary position during a machining operation or move the workpiece, as in rotation around an axis. As used herein, "machining unit" is intended to identify that structure which holds a tool that performs an operation on a workpiece. The tool may be held in a stationary position relative to a moving workpiece, such as in a lathe environment, or may be moved, such as a boring element, relative to a stationary or moving workpiece. While specific machine tool components are shown herein for purposes of illustration, the inventive concept can be practiced with virtually any machine tool consisting of cooperating components, i.e. a workpiece holder and a machining unit.

The frame **42** consists of first and second spaced, disk-shaped end supports **50, 52** with at least one, and in this case four, reinforcing elements **54, 56, 58, 60** extending between the first and second end supports **50, 52** so as to maintain the first and second end supports **50, 52** in a desired operative relationship.

In this embodiment, there are third and fourth disk-shaped end supports **62, 64** between which the reinforcing elements **54, 56, 58, 60** extend so as to likewise maintain the third and fourth end supports **62, 64** in a desired operative relationship with each other and with the first and second end supports **50, 52**.

While the reinforcing elements **54, 56, 58, 60** are shown as extending continuously between each of the first, second, third, and fourth end supports **50, 52, 62, 64**, separate reinforcing elements may be used to connect as between only adjacent end supports **50, 52, 62, 64**.

In this embodiment, adjacent end supports **50, 52**; **50, 62**; and **62, 64**, in conjunction with the reinforcing elements **54, 56, 58, 60**, define individual, caged spaces/compartments **66, 68, 70**.

The overall arrangement of the end supports **50, 52, 62, 64** and reinforcing elements **54, 56, 58, 60** produces a caged module with good structural integrity so as to maintain positive alignment between the machine components thereon, in this case the workpiece holder **44** and machining unit **46**. The structural integrity of the machine tool assembly module is attributable in part to the fact that a series of closed loops are defined throughout. For example, between the end supports **50, 62**, there are three differently oriented closed loops associated with each of the reinforcing elements **54, 56, 58, 60**. Exemplary reinforcing element **54** defines a first closed loop with the end supports **50, 62** and the reinforcing element **56**, a second closed loop with the end supports **50, 62** and the reinforcing element **58**, and third closed loop with the end supports **50, 62** and the reinforcing element **60**.

In this embodiment, each of the end supports **50, 52, 62, 64** has a peripheral edge **72, 74, 76, 78**, with each of the peripheral edges **72, 74, 76, 78** being substantially circular and of equal diameter. The end supports **50, 52, 62, 64** are connected so that the peripheral edges **72, 74, 76, 78** cooperatively produce an overall cylindrical shape.

In this embodiment, each reinforcing element **54, 56, 58, 60** is in the form of an elongate, hollow bar. However, the reinforcing elements **54, 56, 58, 60** could have a solid construction. In this embodiment, the length of the reinforcing elements **54, 56, 58, 60** are substantially parallel to each other and a central machining axis defined by the center of the workpiece **48**, with the reinforcing elements **54, 56, 58, 60** extending fully through each of the end supports **50, 52, 62, 64**. The reinforcing elements **50, 52, 62, 64** could be non-parallel depending upon the desired size and configuration of the space bounded thereby. The reinforcing elements **54, 56, 58, 60** can be fixed to each of the end supports **50, 52, 62, 64** by any suitable means, such as by welding, adhesive, threaded fasteners, or by means of structure described hereinafter.

The workpiece holder **44** is supported on the frame **42** through a base **80** which extends between and surrounds each of, the reinforcing elements **56, 58**. Accordingly, additional closed loops are defined through the base **80** and each of the reinforcing elements **56, 58** and the end supports **50**.

The end support **50** has oppositely facing surfaces **82, 84**. The surface **84** defines a support for the machining unit **46**. In this embodiment, the machining unit **46** consists of a base slide element **86** which is translatable along spaced, elongate guide rails **88, 90** selectively in opposite direction along a line indicated by the double-headed arrow **92**. This movement is imparted by a drive motor **94**. The base slide element **86** supports a second slide element **96** which carries a plurality of tools **98**. The second slide element **96** is movable guidingly along elongate, parallel, guide rails **100, 102** selectively in opposite directions in a line indicated by the double-headed arrow **104**, which is orthogonal to the line indicated by the arrow **92**. Movement of the second slide element is imparted by a drive motor **106**.

In this embodiment, the workpiece **48** is directed from a point of supply through an opening **108** through the end support **64**, an opening **110** through the end support **62** and to and through the workpiece holder **44**. A working end **112** of the workpiece **48** extends through an opening **114** through the end support **50** and through the slide elements **86, 96** so as to be exposed for the performance of a machining operation thereon.

The end supports **50, 52, 62, 64** are spaced from each other depending upon the required size for the particular space/compartment **66, 68, 70** and also depending upon the requirements for mounting surfaces to support different components of the particular machine tool assembly.

Another machine tool assembly, according to the present invention, and modified from that shown in FIGS. **4** and **5**, is the machine tool assembly at **120** in FIGS. **6–8**. The machine tool assembly **120** consists of first, second, third, and fourth disk-shaped end supports **122, 124, 126, 128** which are connected by an elongate, parallel, reinforcing elements **130, 132, 134, 136**, each in the form of a hollow bar of circular cross section. Facing surfaces **138, 140** on the end supports **122, 124** bound a working space/compartment **142** within which a machining operation is performed on a workpiece.

A workpiece holder **144**, in the form of a rotary spindle with a chuck **146** at its free end, supports a workpiece **148** for rotation thereof. The body **150** of the workpiece holder **144** is supported cooperatively by the end supports **124, 126** through which it extends. The workpiece holder **144** has a shaft **152** which projects into the space **154** between the end supports **126, 128** so as to be engagable by an endless belt **156** driven by a motor **158**. The motor **158** has mounting elements **160, 162** which are spaced to attach one each to the end supports **124, 126**.

A machining unit **164** is mounted upon a base **166** which surrounds, and spans between, each of the reinforcing elements **132, 134**. A series of operating tools **168** is mounted upon a turret **170** for rotation about an axis **172** to selectively index desired tools into an active position. The turret **170** is carried on a first slide **174** which in turn is carried on a second slide **176** that is in turn slidably mounted to the base **166**. The second slide **176** is translatable guidingly relative to the base **166** in the line of the double-headed arrow **178** and generally parallel to a rotary axis **180** for the chuck **146** and which defines the central axis for the machine tool assembly module **120**. The first slide **174** is guided in translatory movement relative to the second slide **176** in a line indicated by the double-headed arrow **182**, which is generally orthogonal to the line indicated by the arrow **178**. A motor **184** may be operated to advance the first slide **174** along the axis **182**. A separate motor **186** can be used to advance the second slide **176** relative to the base **166** in the line of the arrow **178**.

It is also possible to reposition the turret **170** along the axis **180** by shifting the entire base **166**, as through a separate motor **188**. The motor **188** may operate a threaded element **190**, as shown schematically in FIG. **8**, and in FIG. **4** on the machine tool assembly **40**, to translate the base **166** on the machine tool assembly **120** and the base **80** on the machine tool assembly **40**.

In FIGS. **9** and **10**, another modified form of machine tool assembly, according to the present invention, is shown at **194**. The machine tool assembly **194** has a frame **42** that is the same as the frame **42** on the machine tool assembly **40**, as shown in FIGS. **4** and **5**. The difference lies in the construction and mounting locations for a workpiece holder **196** and machining unit **198**.

The workpiece holder **196** consists of a base slide element **200** on the surface **82** of the end support **50**, and a second slide element **202** carried by the base slide element **200**. The base slide element **200** is movable guidingly along elongate, parallel rails **204, 206** in a line indicated by the double-headed arrow **208**. The second slide element **202** is in turn guided in linear movement along elongate, parallel rails **210, 212** along a line indicated by the double-headed arrow **214**, which line is orthogonal to the line identified by the double-headed arrow **208**. Movement of the base slide element **200** is imparted by a motor **216**, with movement of the second slide element **202** imparted by a motor **218**. The second slide element **202** has a row of workpieces **220** which are selectively registrable with a tool **222** on the machining unit **198**. The tool **222** is driven in rotation around an axis **224**.

The machining unit **198** has a spindle **226** which is mounted on a base **228** that surrounds and bridges between the reinforcing elements **56, 58**. The base **228** is slidable guidingly parallel to the central operating axis **224** along the reinforcing elements **56, 58**, with movement being imparted by a motor **230** in the space/compartment **70** between the end supports **62, 64**.

In FIG. **11**, a schematic, plan view of the machine tool assembly **194** is shown with closed loops identified by the arrows **232**. The machine tool assembly **194** in FIG. **11** is modified from that in FIG. **10** primarily by reason of different configuration of a workpiece holder **236**, which extends fully through the end support **50**. Closed loops are shown a) through the end support **50**, the reinforcing element **56**, the end support **62** and reinforcing element **58**, b) through the end support **50**, the reinforcing element **56**, the base **228**, and reinforcing element **58**, and c) through the base **228**, the reinforcing element **56**, the end support **62**, and the reinforcing element **58**. The machining unit **198** is further modified from that shown in FIGS. **9** and **10** by reason of the fact that a part **238** of the machine tool assembly **198** is movable transversely to a central axis **240** of the workpiece holder **236**, as indicated by the double-headed arrows **242**.

In FIG. **12**, a modification to the machine tool **40** in FIGS. **4** and **5** is shown. The modification resides in the provision of additional, elongate, reinforcing elements **242, 244**, each in the form of an elongate plate. Exemplary reinforcing element **242** has a body **246** with a W-shaped cross section taken transversely to its length. A central portion **248** of the body **246** wraps around the reinforcing element **54**. End

pieces **250** are integrally joined as part of the body **246** and facilitate attachment of the reinforcing element **242** to each of the end supports **50**, **62**. Threaded fasteners **252** are directed through the end pieces **250** into each of the end supports **50**, **62**. By configuring the body **246** as shown, the reinforcing element **244** can be constructed so as not to extend radially beyond the peripheral edges **72**, **76** of the end supports **50**, **62**.

The reinforcing elements **242**, **244** further rigidify the connection between the end supports **50**, **62**. While two such reinforcing elements **242** are provided, additional, like reinforcing elements might be incorporated in association with each of the reinforcing elements **56**, **58**, so long as they do not interfere with movement of the base **80** on the workpiece holder **44** relative to the frame **42**.

In FIG. **13**, a modified form of reinforcing plate **254** is shown on the machine tool **40**, which can be substituted for, or used in conjunction with, the reinforcing elements **242**, **244**. Each reinforcing element **254** is in the form of an elongate plate. The plates **254** are placed against the peripheral edges **72**, **76**, one each at the location of the reinforcing elements **54**, **56**, **58**, **60**. Each reinforcing plate **254** has an elongate body **256** which is curved to the configuration of the peripheral edges **72**, **76**, and depending flanges **258**, **260** at its opposite ends. The flanges **258**, **260** are connected to oppositely facing surfaces **262**, **84** on the end supports **62**, **50**, through threaded fasteners **264**. The plates **254** further rigidify the overall structure of the machine tool assembly module **40**.

In FIGS. **14–17**, various different cross-sectional configurations for the reinforcing elements **54**, **56**, **58**, **60** are shown. These configurations are only exemplary as other shapes might function equally effectively. In FIG. **14**, a rounded cross-sectional shape, as in FIGS. **4–13**, is shown. In FIG. **15**, a square cross-sectional shape is shown, whereas in FIGS. **16** and **17**, octagonal, and hexagonal cross-sectional shapes are shown. Other polygonal shapes can be utilized.

In FIGS. **18–24**, various configurations of end supports, that might be substituted for the end supports **50**, **52**, **62**, **64**, are shown. Each of the end supports **266**, **268**, **270**, **272** has a disk shape with round peripheral edges **274**, **276**, **278**, **280**. The end supports **266**, **268**, **270**, **272** differ, each from the other, in terms of the number of through holes **282** formed therethrough to accommodate a like number of reinforcing elements **54**, **56**, **58**, **60**. In FIG. **18**, four through holes **282** are formed, with eight, six, and five through holes **282** formed in the end supports **268**, **270**, **272** of FIGS. **19–21**. The through holes **282** in each case are spaced equidistantly from their respective central axis **284**, **286**, **288**, **290** and from each other circumferentially about the axes **284**, **286**, **288**, **290**.

As shown in FIG. **20**, it is preferred that lines L1 and L2 extending from the central axis **288** through two different reinforcing elements through the through holes **282** define an included angle a of at least 90° to give the desired rigidity to the module and, more preferably, at least 120°. In this case, the diametrically opposite location of the through holes **282** contributes to the structural stability of the modules.

In FIGS. **22–24**, three additional configurations for end supports are shown at **292**, **294**, **296**, consecutively. The end support **292** has a rectangular body **298** with projections **300** at each of four corners of the body **298**. Each projection has a throughhole **302** to accept a reinforcing element **54**, **56**, **58**, **60**.

The end support **294** has a square body **302** with through holes **304** adjacent each corner thereof.

The end support **296** has a round body **306** with integrally formed projections **308** equidistantly spaced around the peripheral edge **310** thereon. Each projection **308** has a through hole **312** formed therethrough to accept a reinforcing element **54**, **56**, **58**, **60**.

Each of the end supports **292**, **294**, **296** lends itself to being supported on a flat surface in four different orientations, each rotated through 90° relative to each other around the central axes **314**, **316**, **318** of the end supports **292**, **294**, **296**, consecutively. This permits orientation of the machine tool assembly modules in at least the four different orientations and facilitates stacking, as hereinafter described.

While each of the reinforcing elements **54**, **56**, **58**, **60** is shown as a single piece bar, each reinforcing element can be made in multiple parts, as shown for the elongate reinforcing element **320** in FIGS. **25–27**. This multi-piece construction facilitates assembly to the end supports with one exemplary end support **322** shown in FIGS. **25–27** and corresponding in function to the end supports **50**, **52**, **62**, **64**. The reinforcing element **320** consists of a first part **324** and a second part **326** which is joinable to the first part **324**. The first and second joinable parts **324**, **326** are extendable, one within the other.

In this case, the second part **326** is extendable within the first part at **324**, however this arrangement could be reversed. The first part **324** has an annular inside surface **328**, with the second part having an annular outside surface **330**.

The reinforcing element **320** further includes a wedge assembly **331** with first and second annular wedge elements **332**, **334** which are assembled to be located between the inside surface **328** of the first part and the outside surface **330** of the second part **326**. The second wedge element **334** fits inside of the wedge element **332** so that an outside cam surface **336** of the second wedge element **334** abuts to an inside cam surface **338** of the first wedge element **332**. By moving the first wedge element **332** from right to left over the second wedge element **334**, the combined effective diameter (D) of the wedge elements **332**, **334** increases.

The second part **326** has a reduced diameter free end **340** which is threaded. The inside surface **342** of the second wedge element **334** has a complementary thread to that the reduced diameter free end **340** can be threaded into the second wedge element **334**.

To join the parts **324**, **326**, the second wedge element **334** can be loosely threaded to the free end **340** with the first wedge element **332** in surrounding relationship. The second part **326** can then be advanced into the first part **324** to approximately the desired location. Relative movement of the wedge elements **332**, **334** is accomplished by a wedge repositioning element **344**, which element **344** is substantially cylindrical with an enlarged flange **346** at an end thereof. The diameters of the inside surface **328** and outside surface **330** and thickness T of an annular wall **348** on the wedge repositioning element **344**, are chosen so that with the second part **326** advanced into the first part **324**, a space exists between the outside surface **330** of the second portion **326** and the inside surface **328** of the first part **324** which is sufficient to relatively closely accept the wall **348** of the wedge repositioning element **344**.

By advancing the wedge repositioning element **344** from right to left in FIGS. **25–27**, a leading edge **350** of the wedge repositioning element **344** is abuttable to the first wedge element **332**. Further advancement of the wedge repositioning element **344** causes the first wedge element **332** to shift

from right to left over the second wedge element **334** to thereby tighten the connection between the first and second parts **324**, **326**. Movement of the wedge repositioning element **34** within the first part **324** is limited by an annular shoulder **352** which is abuttable to an edge **354** on the first part **324**.

By reason of the threaded connection between the second part **326** and second wedge element **334**, the second part **326** can be rotated about its central axis **356** to either further advance the.second part **326** into the first part **324**, or fully separate the second part **326** from the first part **324**, depending upon the direction of rotation.

This structure also facilitates a positive securing of the parts **324**, **326** by the performance of an additional step. In the FIG. **26** state, the second part **326** can be drawn by a pulling action to the right in that Figure to shift the second wedge element **334** to the right relative to the first wedge element **332**, thereby enhancing the wedging force between the elements **332**, **334**. This pulling force may be imparted by any of a number of different means **357**, i.e. hydraulic cylinder, etc. The wedge assembly **331** may be temporarily attached to the part **324** or otherwise blocked from left-to-right movement during this pulling step. The second part **326** may remain as part of the reinforcing element **320** in operation or may be removed, substituted for by another element of a desired size and shape, and reused in the manner described above.

The second part **326** threaded into the second wedge element **334** can be driven from right to left in FIG. **26** to disengage the wedge elements **332**, **334**.

Use of the reinforcing element **320** facilitates assembly of the reinforcing element to the end supports. A similar arrangement can be provided at each connection with an end support, i.e. at both ends of the reinforcing elements and at all intermediate connections between the reinforcing elements and end supports.

The above description is focused on the formation of a caged module using reinforcing elements and end supports. The same closed loop structural stability can be realized through other structures. As one example, in FIG. **28**, a substantially fully enclosing frame **358** is shown with an internal chamber **360** to accommodate machine tool assembly components, including a workpiece holder **362** and a machining unit **364**. With this arrangement, closed loops are formed substantially continuously around the central machining axis **366**. The surrounding frame **358**, in conjunction with the workpiece holder **362** and machining unit **364**, defines a module that has structural stability and which can be operated in virtually every conceivable orientation.

In FIGS. **29**–**31**, different frame configurations using the principle of the frame **358** in FIG. **28** are shown. In FIG. **29**, a generally rounded surrounding frame **368** is utilized with a cylindrical frame **370** shown in FIG. **30** and a squared/cubical frame **372** shown in FIG. **31**. Access doors **374**, **376**, **378** may be used to access the internal chambers **380**, **382**, **384** to install the machine tool components identified generally at **386** and install and remove workpieces.

The completed machine tool assembly modules lend themselves to being used in different orientations and stacked to be simultaneously useable in a relatively compact space. Various setups for the exemplary machine tool assembly module **120** will now be described.

In FIG. **32**, the machine tool assembly **120** is mounted on a base **386** consisting of spaced upright **388**, each of which defines an upwardly facing surface **392**, **394**. The uprights **388**, **390** are maintained in a desired spaced relationship by a cross piece **394**. The machine tool assembly module **120** can be rested upon the base **386** by situating the end support **128** on the surface **392** and the end support **122** on the surface **394**. The uprights **388**, **390** can be suitably connected to the end supports **128**, **122** to prevent unwanted rotational movement of the machine tool assembly module on the base surfaces **392**, **394**.

With this arrangement, the structural integrity of the machine tool assembly is maintained as a module independently of the base. Thus, the base need not be made with a large mass to elevate the machine tool assembly **120** to the desired waist height of the operator **396**. Accordingly, heat transferred to the base **386** is minimized. Even if the base **386** does distort, for any reason, this will not adversely affect the alignment of the machine tool components.

While the base **386** permits normal machining operations to be performed using the machine tool assembly **120** thereon, this base also facilitates setup or servicing of individual machine tool assemblies **120** that may be removed from an on line or active position. The individual machine tool assemblies **120** can be moved by a crane, or the like, between an active position and a temporary position on the base **386**.

In FIG. **33**, a base **398** is shown having bar-like components **400** joined to produce squared/cubical compartments **402** that are spaced from each other both horizontally and vertically. Compartments **402** are each sized to loosely receive one of the machine tool assembly modules **120**. Within each compartment are end platforms **404**, **406** defining upwardly facing surfaces **408**, **410** to bear upon the end supports **128**,**122** on the machine tool assembly module **120**.

The base **398** can be set up to accept any number of different machine tool assembly modules **120** which can be operated simultaneously in the compartments **402**. This utilizes space in a vertical direction that is often unused in many machining facilities.

Further modified forms of bases are shown in FIGS. **34** and **35** at **412** and **414**, respectively. The base **412** has a squared base portion **416** defining a reservoir **418** and an upwardly facing peripheral edge **420** extending around the reservoir **418** at the top of the base portion **412**. Spaced, parallel edge portions **422**, **424** are spaced a distance equal to the spacing between the end supports **122**, **128** on the machine tool assembly module **120**. Accordingly, the machine tool assembly module **120** can be supported through the end supports **122**, **128** upon the edges **422**, **424** and above the reservoir **418** so that lubricant and portions of workpieces removed during a machining operation can be collected in the reservoir **418**.

The base includes inverted Y-shaped frames **426** which define spaced edges **428**, **430** to bear on end supports **122**, **128** to maintain additional machine tool assembly modules **120** in an operative position above those resting on the base edges **422**, **424**.

The frames **426** have uprights **432**,**434**,**436**. The uprights **432**,**434** support horizontal frame parts **438** which define the supporting edges **428**, **430**. The uprights **432**, **434**, **436** also define a foundation for connectors **440** which are usable to join the end supports **122**, **128** to the base **412**.

The base **412** thus defines a stepped arrangement for supporting machine tool assembly modules **120** in vertically spaced and horizontally staggered relationship so that machining fluids and workpiece particles removed during the machining operation can be accumulated within the reservoir **418** without being deposited on an underlying machine tool assembly module **120**.

The base **414** in FIG. **35** is similar to the base **412** in FIG. **34**, with the exception that frames **442**, corresponding to the frames **426**, have an additional "step" defined by an additional horizontal frame part **444** and additional, horizontally spaced uprights **446,448** for each frame part **444**. The base part **450**, corresponding to the base part **416**, is dimensioned to accommodate the additional two machine tool assembly modules **120**. The machine tool assembly modules **120** are assembled to the base **414** in the same manner and held in place by like connectors **440**.

Another aspect of the invention is shown in FIG. **36** using one of the exemplary machine tool assembly modules **40**. Each of the reinforcing elements **54, 56, 58, 60** is shown with a hollow configuration so that each of the reinforcing elements **54, 56, 58, 60** has an internal passageway **452** defined therethrough.

According to the invention, separate manifolds **454,456** are mounted to the ends of the reinforcing elements **54, 56, 58, 60**. A temperature controlling fluid from a supply **458** is delivered under pressure generated by a pump **460** through an inlet pipe **462**, to the manifold **454** for distribution through each of the passageways **452** in the reinforcing elements **54, 56, 58, 60**, and through the outlet manifold **456** to a return pipe **464** for delivery back to the supply **458**. By operating the pump **460**, a continuous circulation of temperature controlling fluid can be supplied through the reinforcing elements **54, 56, 58, 60**. By reason of the contact between the reinforcing elements **54, 56, 58, 60** and the end supports **50, 52, 62, 64**, temperature control of the entire frame **42** may be effected.

The temperature of the circulated fluid may be elevated at startup and may be cooled to lower the temperature of the system after running thereof. A fluid heater **466** and cooler **468** are provided and selectively operable to controllably raise and lower the temperature of the temperature controlling fluid.

The foregoing disclosure of specific embodiments is intended to be illustrative of the broad concepts comprehended by the invention.

What is claimed is:

1. A machine tool assembly comprising:

a frame;

a workpiece holder capable of grippingly engaging a workpiece; and

at least one machining unit that is operable to perform an operation on a workpiece in an operative position on the workpiece holder,

wherein the frame comprises first and second spaced end supports and at least one reinforcing element which extends between the first and second end supports and which can be fixed relative to the at least one reinforcing element so as to maintain the first and second end supports in a desired operative relationship,

the first and second spaced end supports respectively having first and second surfaces which face each other and bound a working space,

the workpiece holder and at least one machining unit each connected to at least one of the first and second end supports and at least one reinforcing element so that the at least one machining unit can be operated to perform a machining operation on a workpiece in an operative position on the workpiece holder,

the workpiece holder residing at least partially within the working space.

2. The machine tool assembly according to claim **1** wherein the first and second end supports each comprise a disk-shaped element and the at least one reinforcing element comprises a first elongate bar.

3. The machine tool assembly according to claim **2** wherein the first elongate bar extends through at least one of the first and second end supports.

4. The machine tool assembly according to claim **2** wherein the frame further comprises a second elongate bar, each of the first and second elongate bars has a length, and the lengths of the first and second elongate bars are substantially parallel.

5. The machine tool assembly according to claim **4** wherein the frame further comprises a third elongate bar.

6. The machine tool assembly according to claim **2** wherein the frame further comprises a third disk-shaped element which is connected, and can be fixed relative, to the first elongate bar.

7. The machine tool assembly according to claim **1** wherein the at least one reinforcing element comprises a first elongate bar having a length and a cross-sectional configuration transversely to the length of the first elongate bar that is substantially circular.

8. The machine tool assembly according to claim **1** wherein the first and second end support each comprise a disk-shaped element having a perimeter edge defining substantially a circular shape.

9. The machine tool assembly according to claim **1** wherein the first and second end support each comprise a disk-shaped element having a perimeter edge defining substantially a square shape.

10. The machine tool assembly according to claim **1** wherein the first and second end supports each comprise a disk-shaped element having a perimeter edge defining spaced projections which may be bridged by a support upon which the machine tool assembly is placed.

11. The machine tool assembly according to claim **1** wherein the first and second end support and at least one reinforcing element cooperatively define a caged working space within which a machining operation may be performed by the at least one machining unit.

12. The machine tool assembly according to claim **11** wherein the first and second end support have a peripheral edge with a shape and the shape of the peripheral edges of the first and second end support is substantially the same.

13. The machine tool assembly according to claim **1** wherein the at least one reinforcing element comprises a first elongate bar having a length and a cross-sectional configuration of the first elongate bar transversely to the length of the first elongate bar is polygonal.

14. A machine tool assembly comprising:

a frame;

a workpiece holder; and

at least one machining unit that is operable for performing an operation on a workpiece in an operative position on the workpiece holder,

wherein the frame comprises first and second spaced end supports and at least one reinforcing element which extends fully between and connects to each of the first and second end supports so as to maintain the first and second end supports in a desired operative relationship,

the workpiece holder and at least one machining unit each connected to at least one of the first and second end supports and at least one reinforcing element so that the at least one machining unit can be operated to perform a machining operation on a workpiece in an operative position on the workpiece holder,

wherein the first and second end supports each comprises a disk-shaped element and the at least one reinforcing element comprises a first elongate plate.

15. The machine tool assembly according to claim **14** wherein the frame further comprises a second elongate plate which connects to the first and second end supports.

16. A machine tool assembly comprising:

a frame;

a workpiece holder; and

at least one machining unit that is operable for performing an operation on a workpiece in an operative position on the workpiece holder,

wherein the frame comprises first and second spaced end supports and at least one reinforcing element which extends between the first and second end supports so as to maintain the first and second end supports in a desired operative relationship,

the workpiece holder and at least one machining unit each connected to at least one of the first and second end supports and at least one reinforcing element so that the at least one machining unit can be operated to perform a machining operation on a workpiece in an operative position on the workpiece holder,

wherein the at least one reinforcing element comprises a first elongate bar, and the first elongate bar comprises first and second joinable parts.

17. The machine tool assembly according to claim **16** wherein the first and second joinable parts are extendable one within the other.

18. The machine tool assembly according to claim **17** wherein the first joinable part has an annular inside surface and the second joinable part has an annular outside surface, the at least one reinforcing element comprises a wedge assembly comprising a first wedge element between the annular inside surface of the first joinable part and the annular outside surface of the second joinable part.

19. The machine tool assembly according to claim **18** wherein the wedge assembly further comprises a second wedge element between the annular inside surface of the first joinable part and the annular outside surface of the second joinable part.

20. The machine tool assembly according to claim **18** wherein the frame, workpiece holder, and at least one machining unit define a machine tool module that can be operated in any orientation.

21. The machine tool assembly according to claim **19** wherein the first and second wedge elements act directly against each other.

22. The machine tool assembly according to claim **21** wherein the second wedge element is threadably engaged with the second joinable part.

23. The machine tool assembly according to claim **21** wherein the wedge assembly further comprises a wedge repositioning element which can be directed into the first joinable part to reposition at least one of the first and second wedge elements.

24. The machine tool assembly according to claim **23** wherein the first joinable part has an end and the wedge repositioning element has a shoulder which is abuttable to the end of the first joinable part to limit movement of the wedge repositioning element into the first joinable part.

25. A machine tool assembly comprising:

a frame;

a workpiece holder; and

at least one machining unit that is operable for performing an operation on a workpiece in an operative position on the workpiece holder,

wherein the frame comprises first and second spaced end supports and at least one reinforcing element which extends between the first and second end supports so as to maintain the first and second end supports in a desired operative relationship,

the workpiece holder and at least one machining unit each connected to at least one of the first and second end supports and at least one reinforcing element so that the at least one machining unit can be operated to perform a machining operation on a workpiece in an operative position on the workpiece holder,

wherein the at least one reinforcing element comprises a first elongate bar having a through passageway to permit passage of a coolant through the first elongate bar.

26. A machine tool assembly:

a frame;

a workpiece holder;

at least one machining unit that is operable for performing an operation on a workpiece in an operative position on the workpiece holder,

wherein the frame comprises first and second spaced end supports and at least one reinforcing element which extends between the first and second end supports so as to maintain the first and second end supports in a desired operative relationship,

the workpiece holder and at least one machining unit each connected to at least one of the first and second end supports and at least one reinforcing element so that the at least one machining unit can be operated to perform a machining operation on a workpiece in an operative position on the workpiece holder,

wherein the at least one reinforcing element comprises a first elongate bar having a through passageway; and

a temperature controlling fluid that is directed through the passageway of the first elongate bar.

27. A machine tool assembly comprising:

a frame;

a workpiece holder; and

at least one machining unit that is operable for performing an operation on a workpiece in an operative position on the workpiece holder,

wherein the frame comprises first and second spaced end supports and at least one reinforcing element which extends between the first and second end supports so as to maintain the first and second end supports in a desired operative relationship,

the workpiece holder and at least one machining unit each connected to at least one of the first and second end supports and at least one reinforcing element so that the at least one machining unit can be operated to perform a machining operation on a workpiece in an operative position on the workpiece holder,

wherein the first and second end supports each comprises a disk-shaped element and the at least one reinforcing element comprises a first elongate bar,

wherein the first and second end supports respectively have first and second facing surfaces which bound a working space and the at least one machining unit is mounted to the first facing surface.

28. A machine tool assembly comprising:

a frame;

a workpiece holder; and

at least one machining unit that is operable for performing an operation on a workpiece in an operative position on the workpiece holder,

wherein the frame comprises first and second spaced end supports and at least one reinforcing element which extends between the first and second end supports so as to maintain the first and second end supports in a desired operative relationship,

the workpiece holder and at least one machining unit each connected to at least one of the first and second end supports and at least one reinforcing element so that the at least one machining unit can be operated to perform a machining operation on a workpiece in an operative position on the workpiece holder,

wherein the first and second end supports each comprise a disk-shaped element and the at least one reinforcing element comprises a first elongate bar,

wherein the first end support has oppositely facing first and second surfaces on first and second opposite sides of the first end support, the workpiece holder is on the first side of the first end support, and the at least one machining unit is on the second side of the first end support.

29. The machine tool assembly according to claim **28** wherein the first end support has an opening through which a workpiece held by the workpiece holder can be directed to be operated upon by the at least one machining unit.

30. A machine tool assembly comprising:

a frame;

a workpiece holder; and

at least one machining unit that is operable for performing an operation on a workpiece in an operative position on the workpiece holder,

wherein the frame comprises first and second spaced end supports and at least one reinforcing element which extends between the first and second end supports so as to maintain the first and second end supports in a desired operative relationship,

the workpiece holder and at least one machining unit each connected to at least one of the first and second end supports and at least one reinforcing element so that the at least one machining unit can be operated to perform a machining operation on a workpiece in an operative position on the workpiece holder,

wherein the frame defines a passageway for guiding movement of a temperature controlling fluid.

31. The machine tool assembly according to claim **30** wherein the at least one reinforcing element comprises a first elongate hollow bar, the frame further comprises a second elongate hollow bar extending between the first and second end supports, and the passageway is defined through the first and second elongate hollow bars.

32. The machine tool assembly according to claim **31** wherein the passageway is a continuous passageway which permits circulation of a temperature controlling fluid.

33. The machine tool assembly according to claim **31** further comprising a pump for circulating temperature controlling fluid in the passageway.

34. The machine tool assembly according to claim **33** further comprising a temperature controlling fluid in the passageway.

35. In combination:

a base; and

a first machine tool assembly that can be placed in an operative position on the base in an elevated position over a subjacent support surface, said first machine tool assembly comprising:

a frame;

a workpiece holder;

at least one machining unit that is operable to perform an operation on a workpiece in an operative position on the workpiece holder,

wherein the frame comprises first and second spaced end supports and at least one reinforcing element which extends between the first and second end supports so as to maintain the first and second end supports in a desired operative relationship,

the workpiece holder and at least one machining unit each connected to at least one of the first and second end supports and at least one reinforcing element so that the at least one machining unit can be operated to perform an operation on a workpiece in an operative position on the workpiece holder; and

a second machine tool assembly substantially the same as the first machine tool assembly that can be placed in an operative position on the base in an elevated position over a subjacent support surface so that machining operations can be performed simultaneously by the first and second machine tool assemblies.

36. The combination according to claim **35** wherein the base defines a reservoir for collection of particles of workpieces and machining fluids generated during machining operations.

37. The combination according to claim **35** wherein the base defines stepped surfaces for the first and second machine tool assemblies.

38. The combination according to claim **37** wherein the end supports of the first and second machine tool assemblies are supported directly against the base.

39. The combination according to claim **38** wherein the at least one reinforcing element on the first and second machine tool assemblies does not directly engage the base.

40. The combination according to claim **38** further comprising connectors joining between the base and at least one of the end supports on each of the first and second machine tool assemblies to maintain the first and second machine tool assemblies in the operative position on the base.

41. The combination according to claim **35** wherein the end supports on the first and second machine tool assemblies each have a peripheral edge that is substantially circular.

42. In combination:

a base; and

a first machine tool assembly that can be placed in an operative position on the base in an elevated position over a subjacent support surface, said first machine tool assembly comprising:

a frame;

a workpiece holder; and

at least one machining unit that is operable to perform an operation on a workpiece in an operative position on the workpiece holder,

wherein the frame comprises first and second spaced end supports at least one reinforcing element which extends between the first and second end supports so as to maintain the first and second end supports in a desired operative relationship,

the workpiece holder and at least one machining unit each connected to at least one of the first and second end supports and at least one reinforcing element so that the at least one machining unit can be operated to perform an operation on a workpiece in an operative position on the workpiece holder,

wherein the base comprises a frame defining a plurality of compartments each configured to receive a

machine tool assembly the same as the first machine tool assembly.

43. A machine tool assembly module comprising:

a frame;

a workpiece holder capable of grippingly engaging a workpiece; and

at least one machining unit that is operable to perform an operation on a workpiece in an operative position on the workpiece holder,

wherein the frame defines a cage with an external surface which is structurally reinforced to allow the machine tool assembly module to be supported on a base and operated with the base selectively bearing on a plurality of different portions of the cage which thereby permits different portions of the external surface of the machine tool assembly module to be placed against a support surface to permit performance of a machining operation with the machine tool assembly module in different orientations,

wherein the frame comprises fixed facing surfaces bounding a working space and the workpiece holder resides at least partially within the working space.

44. The machine tool assembly module according to claim **43** wherein the frame has a lengthwise axis and the external surface of the frame is configured to extend substantially fully around the lengthwise axis.

45. The machine tool assembly module according to claim **44** wherein the frame comprises first and second end supports and at least one reinforcing element which extends between the first and second end supports so as to maintain the first and second end supports in a desired operative relationship.

46. The machine tool assembly module according to claim **43** wherein the frame comprises first and second end supports and at least one reinforcing element which extends between the first and second end supports so as to maintain the first and second end supports in a desired operative relationship.

47. The machine tool assembly module according to claim **46** wherein the frame has a central, lengthwise axis and further comprises a second reinforcing element which extends between the first and second end supports, and first and second lines extending from the central axis through the first and second reinforcing elements define an included angle of at least 90°.

48. The machine tool assembly module according to claim **46** wherein the frame has a central, lengthwise axis and further comprises a second reinforcing element which extends between the first and second end supports, and first and second lines extending from the central axis through the first and second reinforcing elements define an included angle of at least 120°.

49. The machine tool assembly module according to claim **46** wherein the frame has a central lengthwise axis and comprises a second reinforcing element which extends between the first and second end supports, the first and second end supports each comprising an elongate bar, and the first and second elongate bars are diametrically oppositely situated relative to the elongate central axis.

50. The machine tool assembly module according to claim **43** wherein the frame has a central, lengthwise axis, the external surface defines a rounded shape, and the machine tool assembly module can be operated with a support base bearing upon the external surface at any location on the surface around the central axis.

51. The machine tool assembly module according to claim **43** wherein the external surface defines a squared shape with flat surface portions and the machine tool assembly module can be operated with a support base bearing on any of the flat surface portions.

52. The machine tool assembly module according to claim **43** wherein the external surface defines a cylindrical shape.

53. A machine tool assembly module comprising:

a frame;

a workpiece holder; and

at least one machining unit that is operable to perform an operation on a workpiece in an operative position on the workpiece holder,

wherein the frame defines a cage with an external surface which is structurally reinforced and permits different portions of the external surface of the machine tool assembly module to be placed against a support surface to permit performance of a machining operation with different portions of the external surface of the cage on the machine tool assembly module bearing on the support surface,

wherein the frame comprises facing surfaces spaced from each other along a first axis bounding a working space,

wherein the machining unit is capable of driving a machining tool around a second axis substantially parallel to the first axis.

* * * * *

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Miyano

(10) Patent No.: US 6,637,097 B2
(45) Date of Patent: Oct. 28, 2003

(54) **SYSTEM AND METHOD FOR PROCESSING ELONGATE WORKPIECES**

(76) Inventor: **Toshiharu Miyano**, 50 Dundee La., Barrington Hills, IL (US) 60010

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/946,646**

(22) Filed: **Sep. 4, 2001**

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Related U.S. Application Data

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(51) **Int. Cl.**[7] **B23Q 41/00**

(52) **U.S. Cl.** .... **29/564**; 29/27 C; 29/27 R; 29/563; 29/33 P; 414/280; 82/124; 82/1.11

(58) **Field of Search** .... 29/27 C, 27 R, 29/563, 564, 33 P; 414/280, 751.1, 18; 82/124, 127, 129, 1.11

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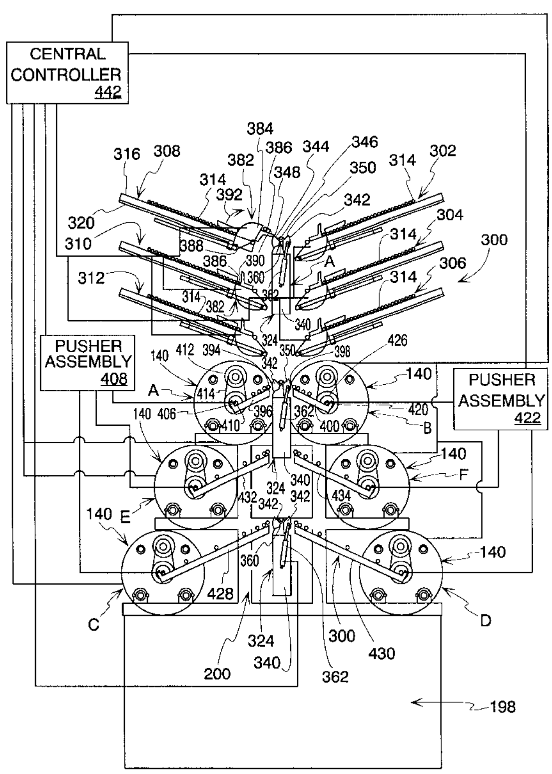
Primary Examiner—A. L. Wellington
Assistant Examiner—Dana Ross
(74) *Attorney, Agent, or Firm*—Wood, Phillips, Katz, Clark & Mortimer

(57) **ABSTRACT**

A system for processing elongate workpieces. The system consists of a first machining unit for performing a first processing operation on an elongate workpiece that is situated at a first location and a second machining unit for performing a second processing operation on an elongate workpiece that is situated at a second location that is vertically spaced from the first location. The system further consists of a first supply unit on which a plurality of elongate workpieces can be placed in a stored position. A transfer assembly engages an elongate workpiece in a stored position and selectively delivers an elongate workpiece engaged by the transfer assembly to one of the first and second locations.

36 Claims, 14 Drawing Sheets



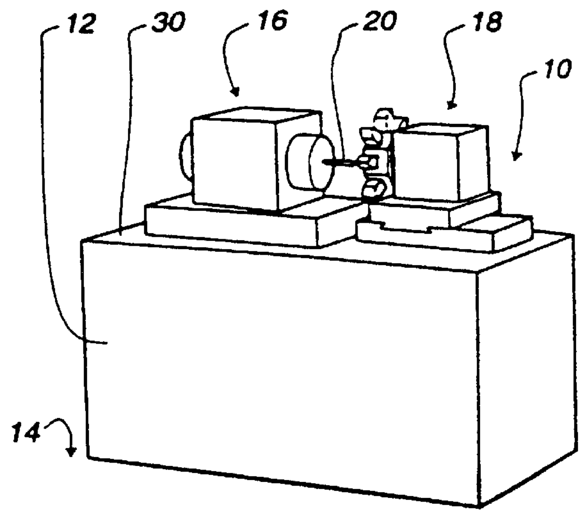


Fig. 1
(Prior Art)

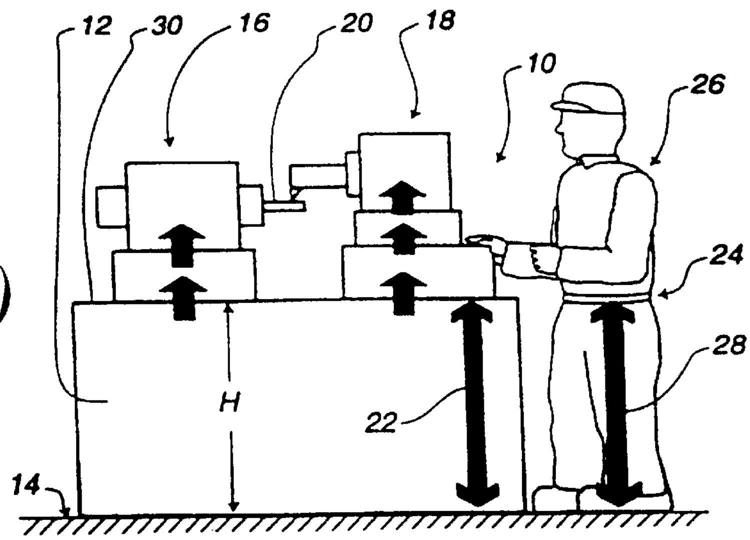


Fig. 2
(Prior Art)

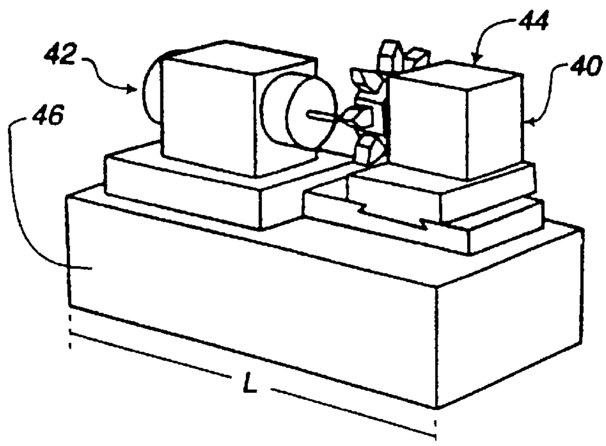


Fig. 3

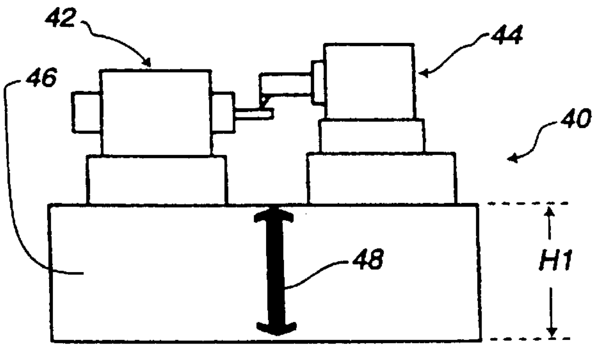


Fig. 4

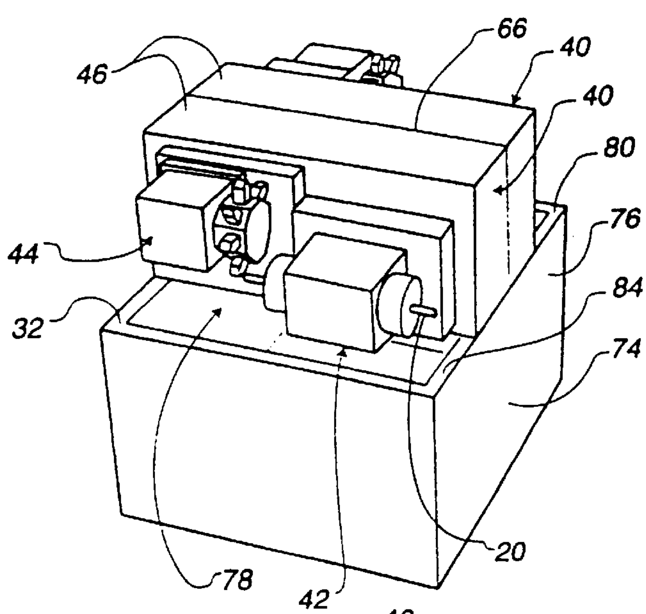


Fig. 5

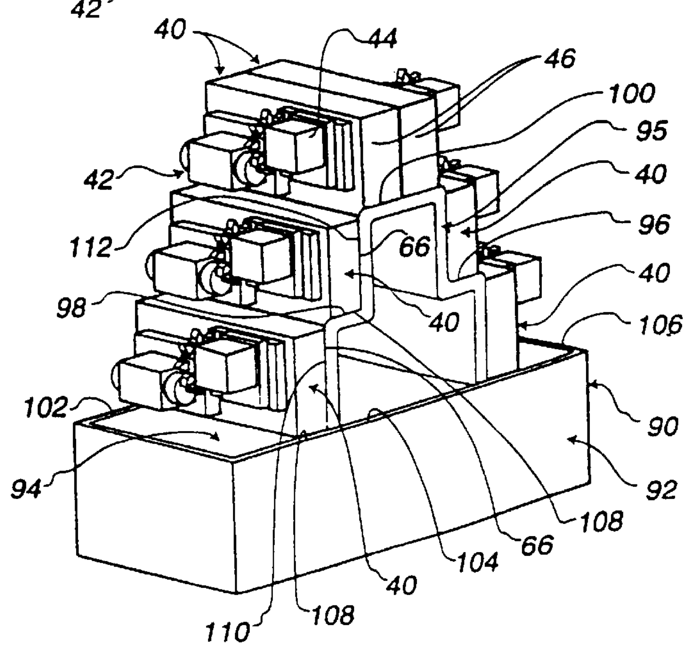
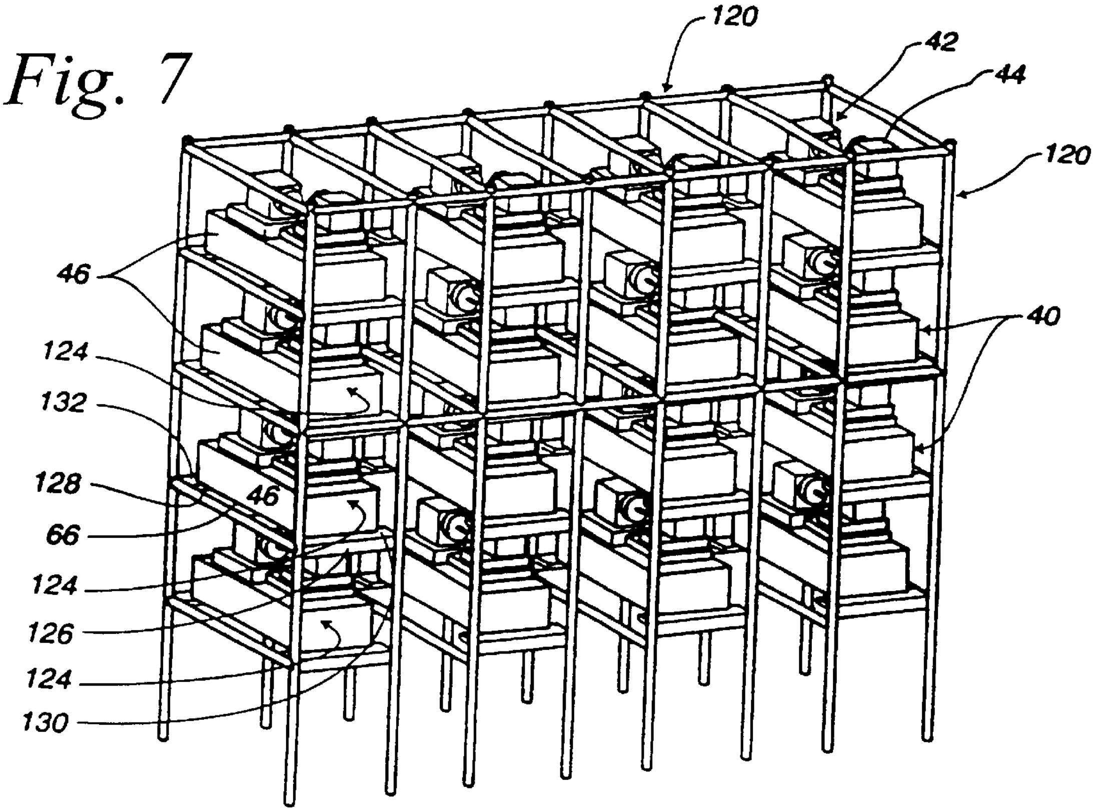


Fig. 6

Fig. 7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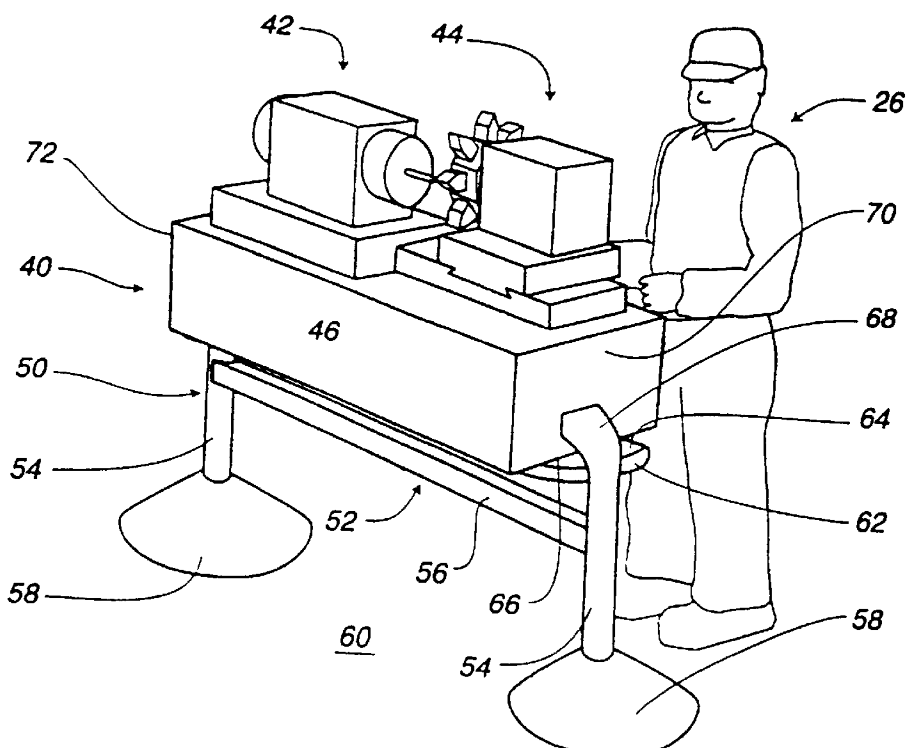
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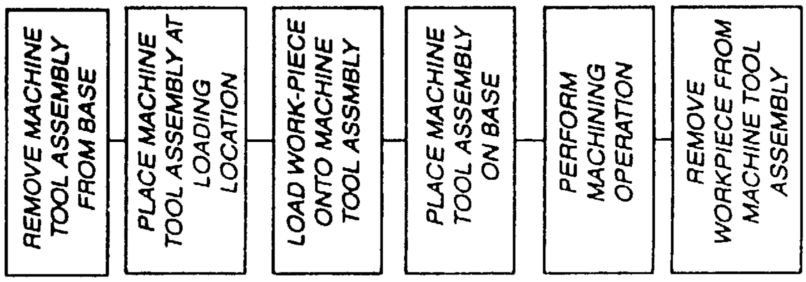
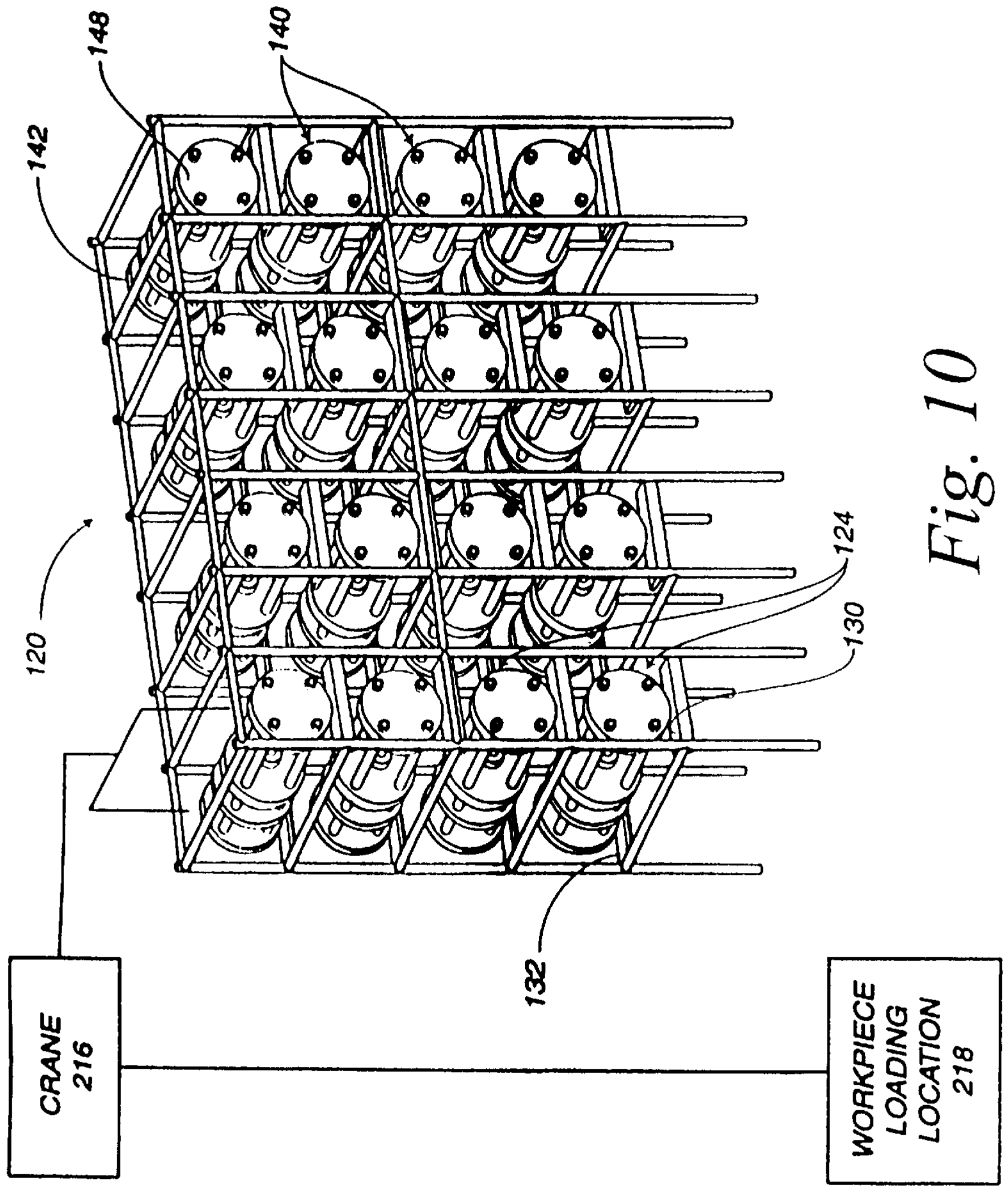
Fig. 8



REMOVE MACHINE TOOL ASSEMBLY FROM BASE
PLACE MACHINE TOOL ASSEMBLY AT LOADING LOCATION
LOAD WORK-PIECE ONTO MACHINE TOOL ASSMBLY
PLACE MACHINE TOOL ASSEMBLY ON BASE
PERFORM MACHINING OPERATION
REMOVE WORKPIECE FROM MACHINE TOOL ASSEMBLY

Fig. 13



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CRANE 216
WORKPIECE LOADING LOCATION 218

Fig. 10

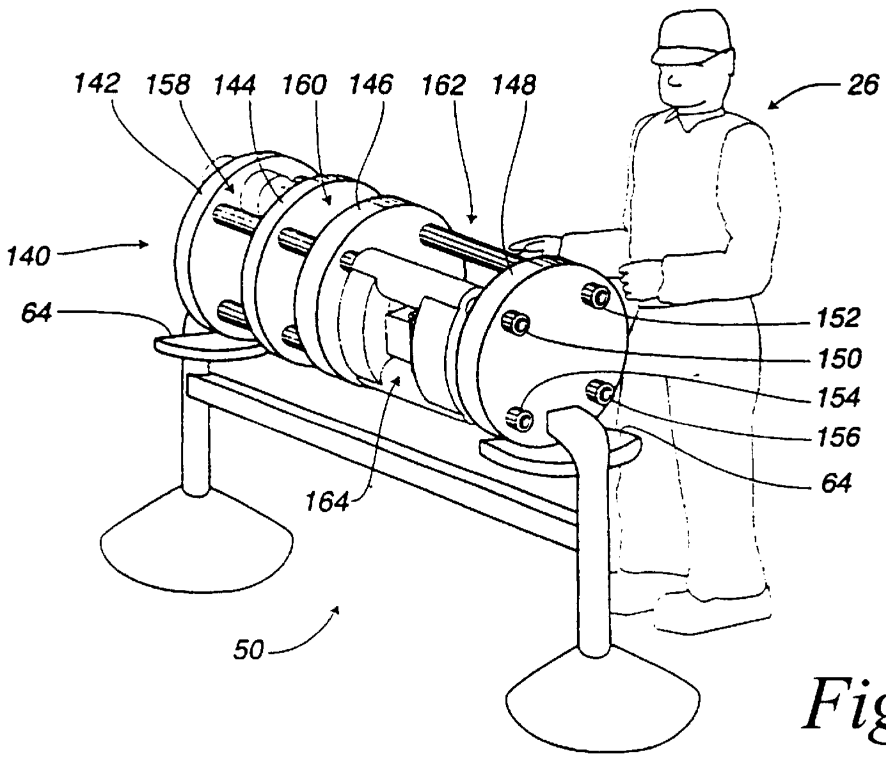
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Fig. 9

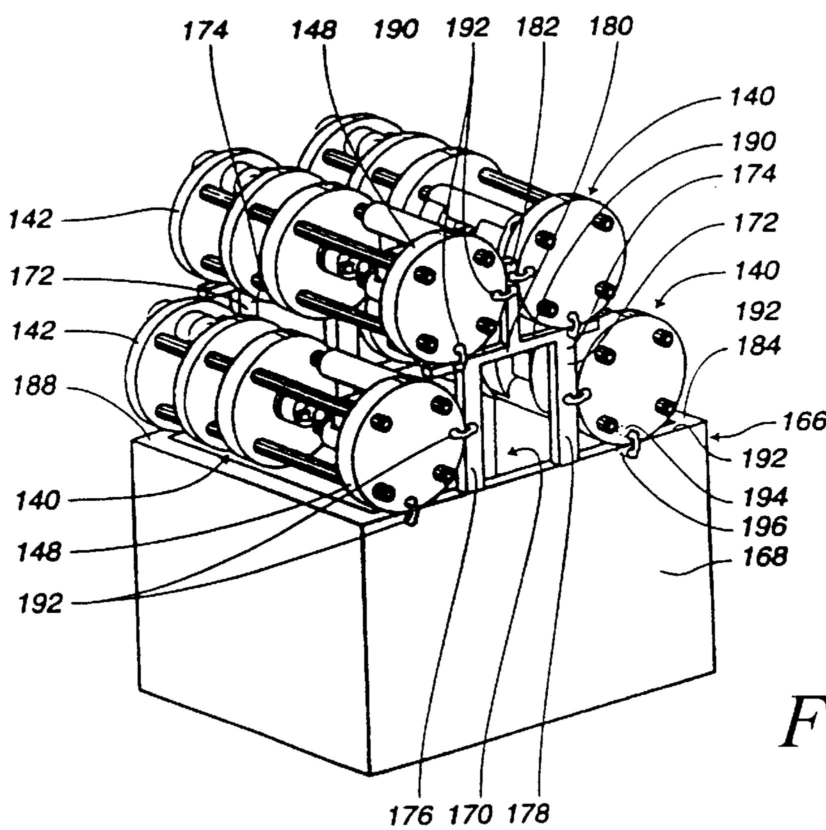
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Fig. 11

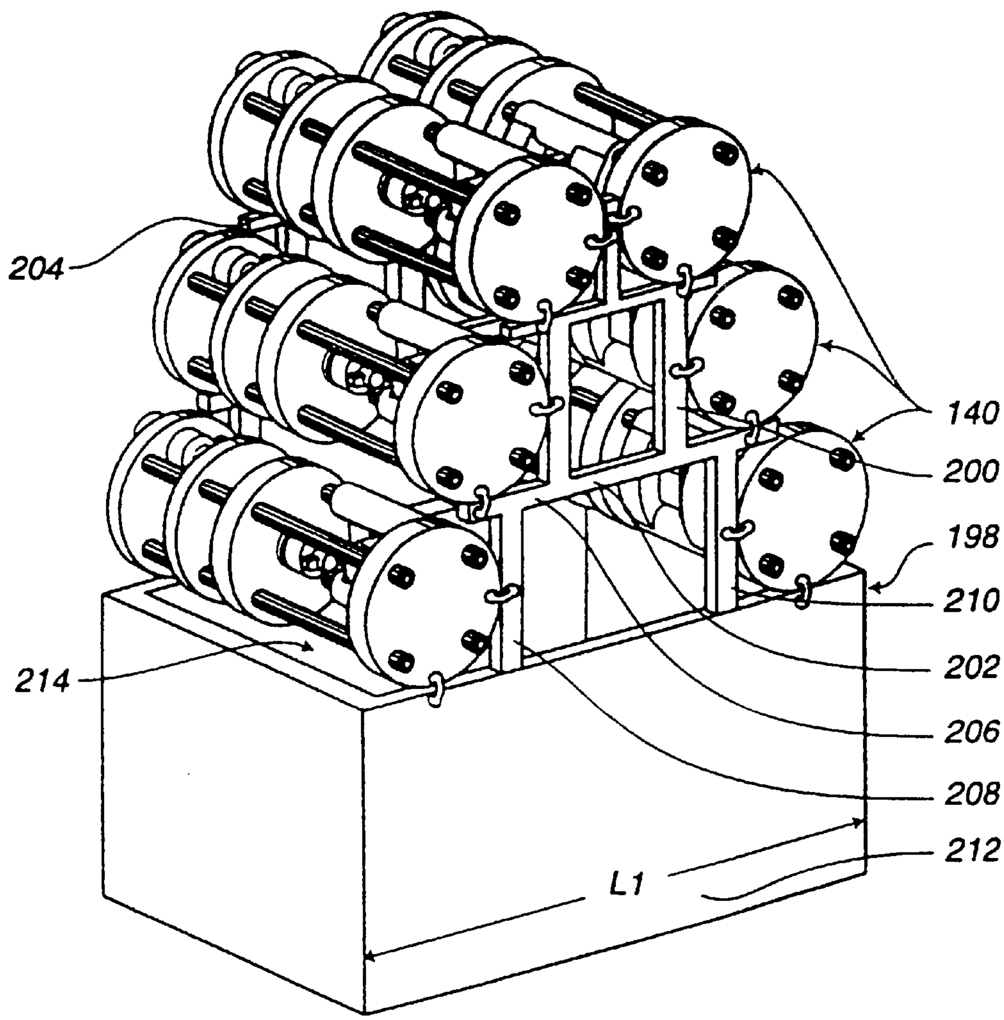

Fig. 12

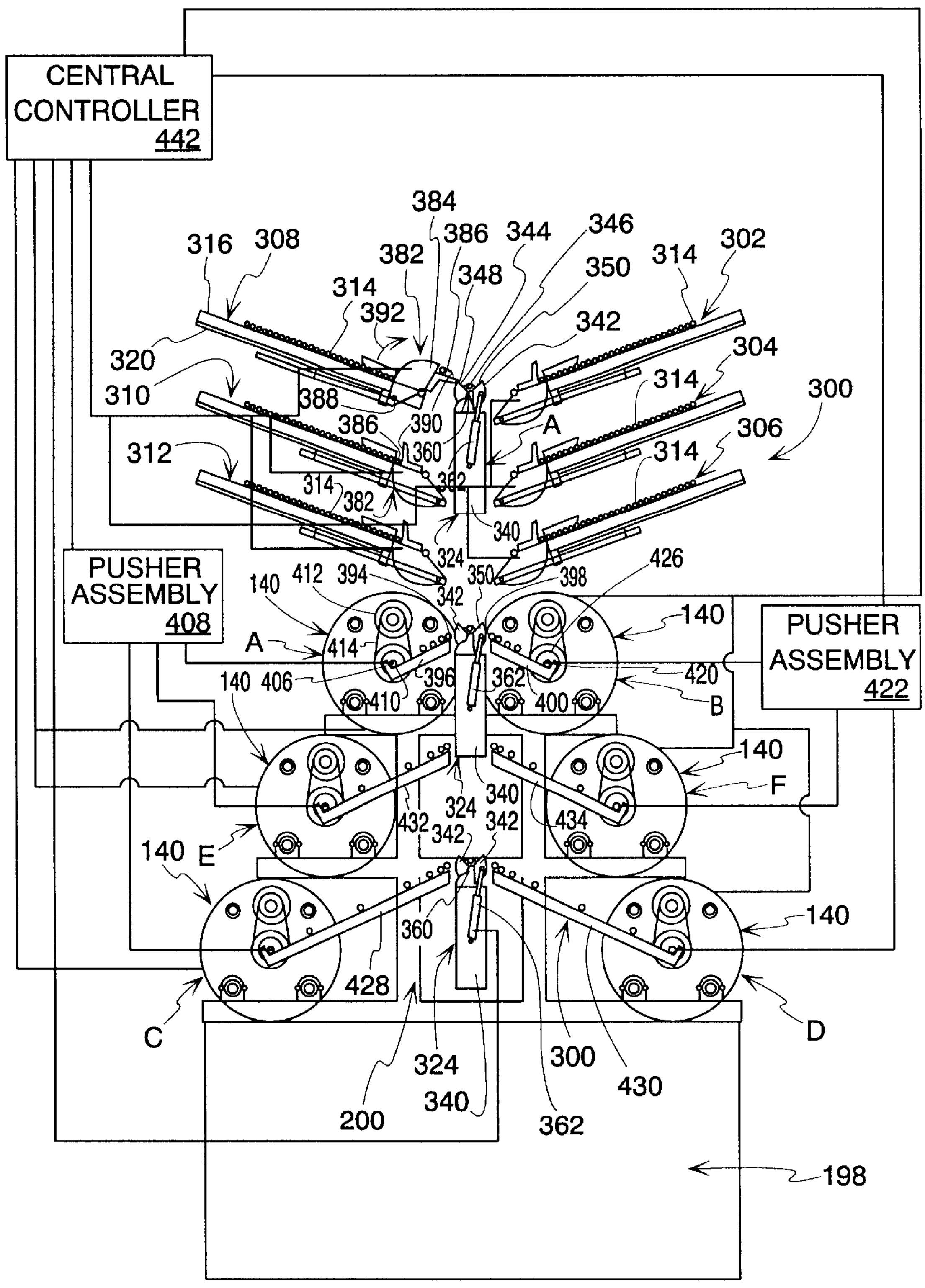
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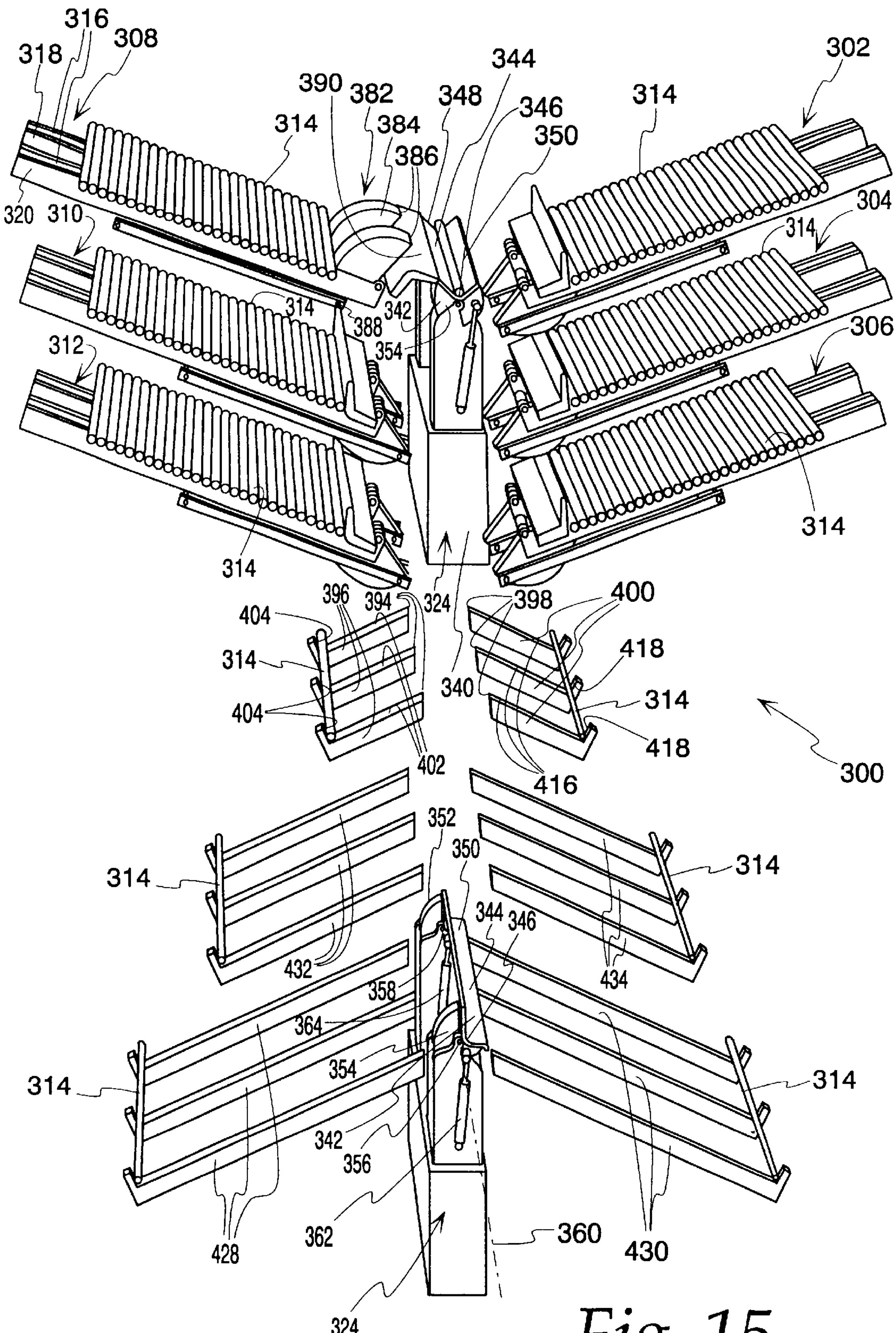
Fig. 14



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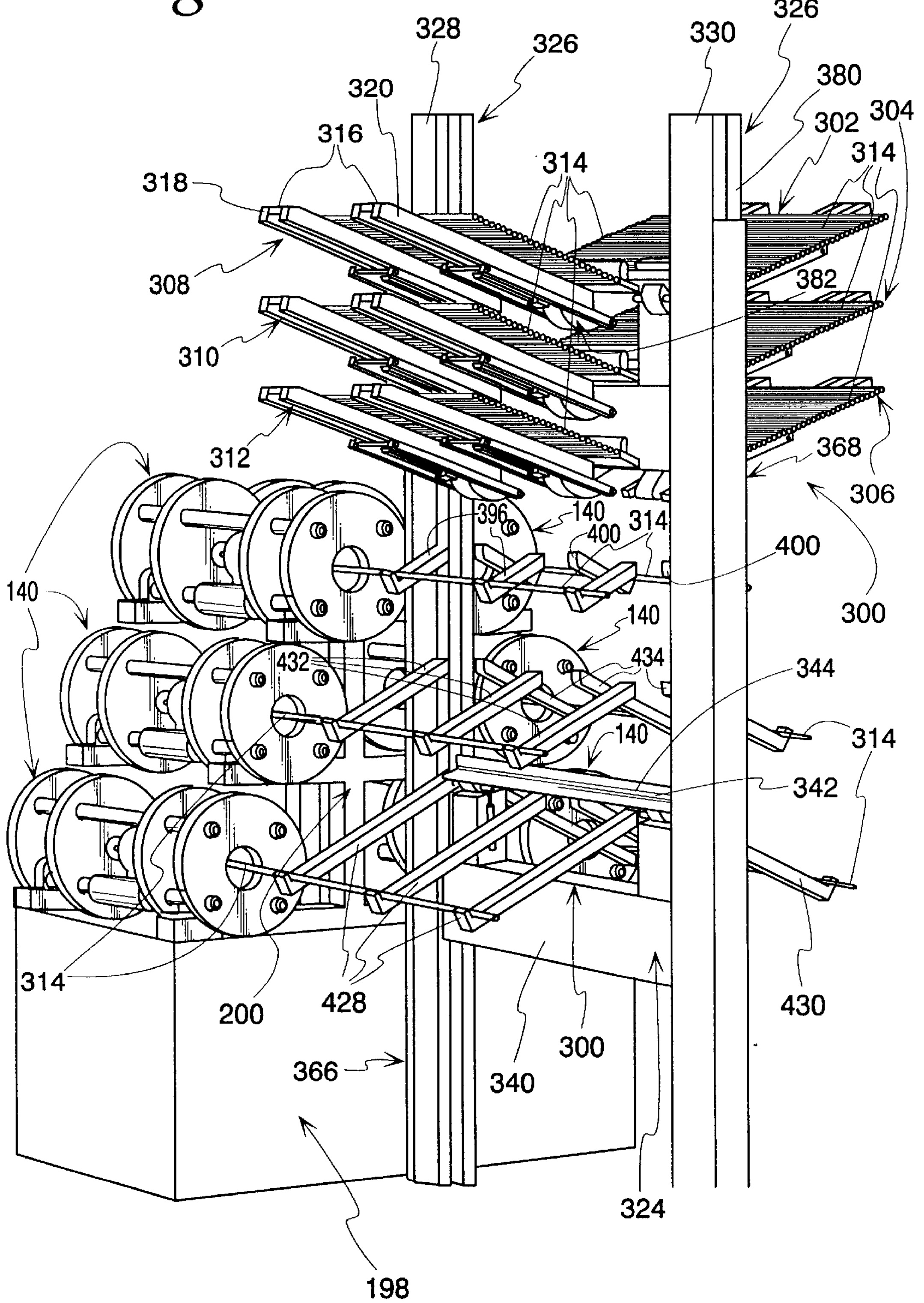
430
428
324

Fig. 15

Fig. 16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198

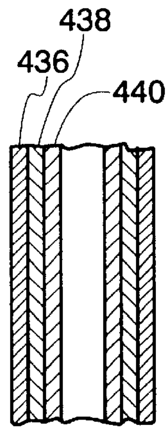
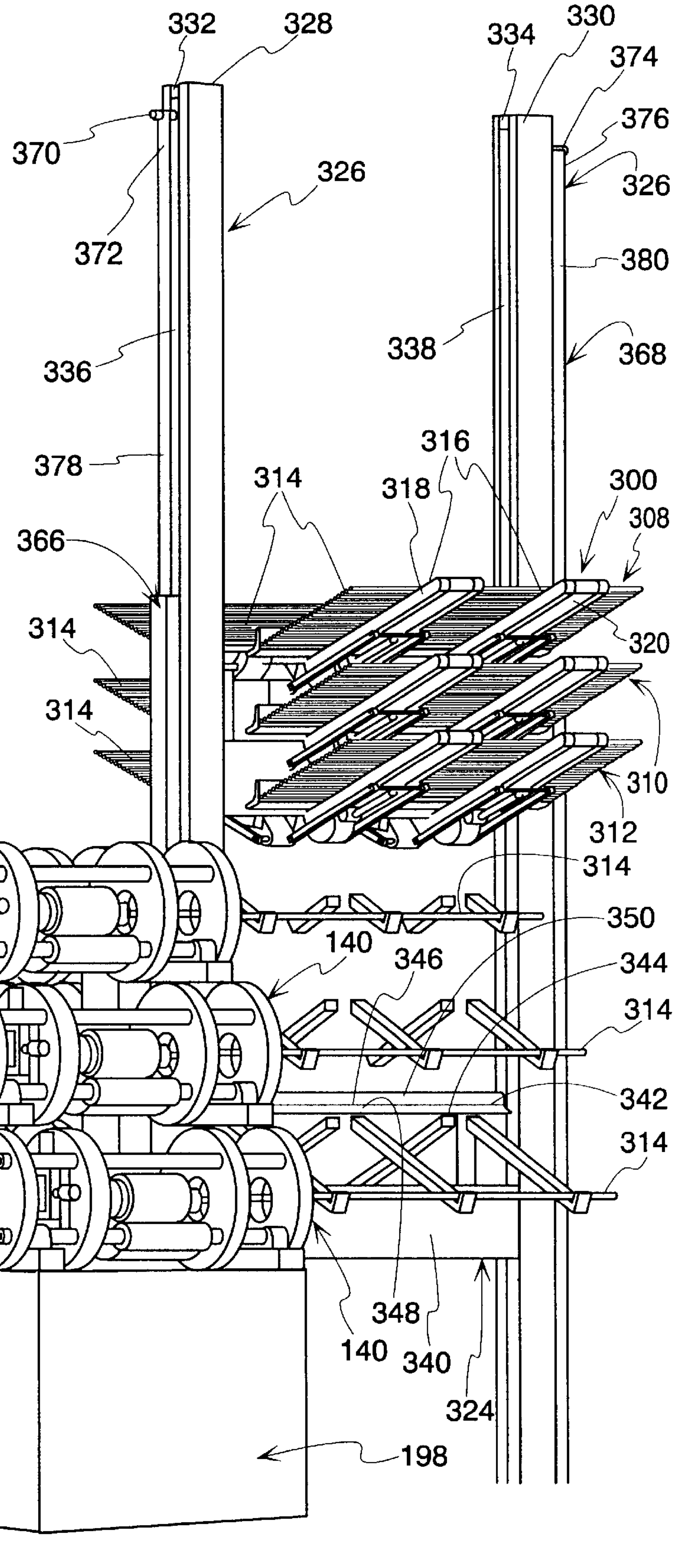

438
436
440

Fig. 18

Fig. 17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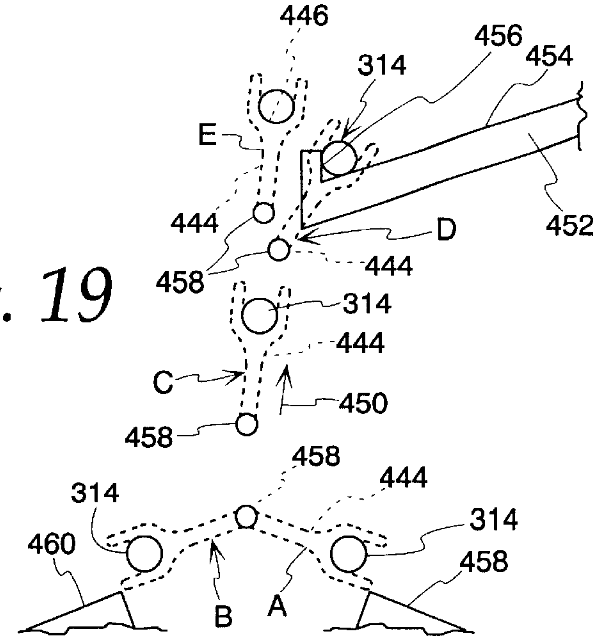

Fig. 19

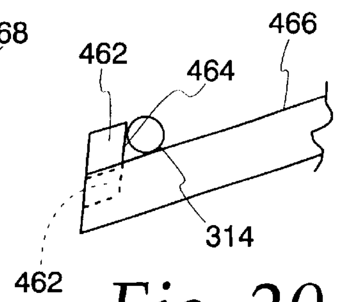

Fig. 20

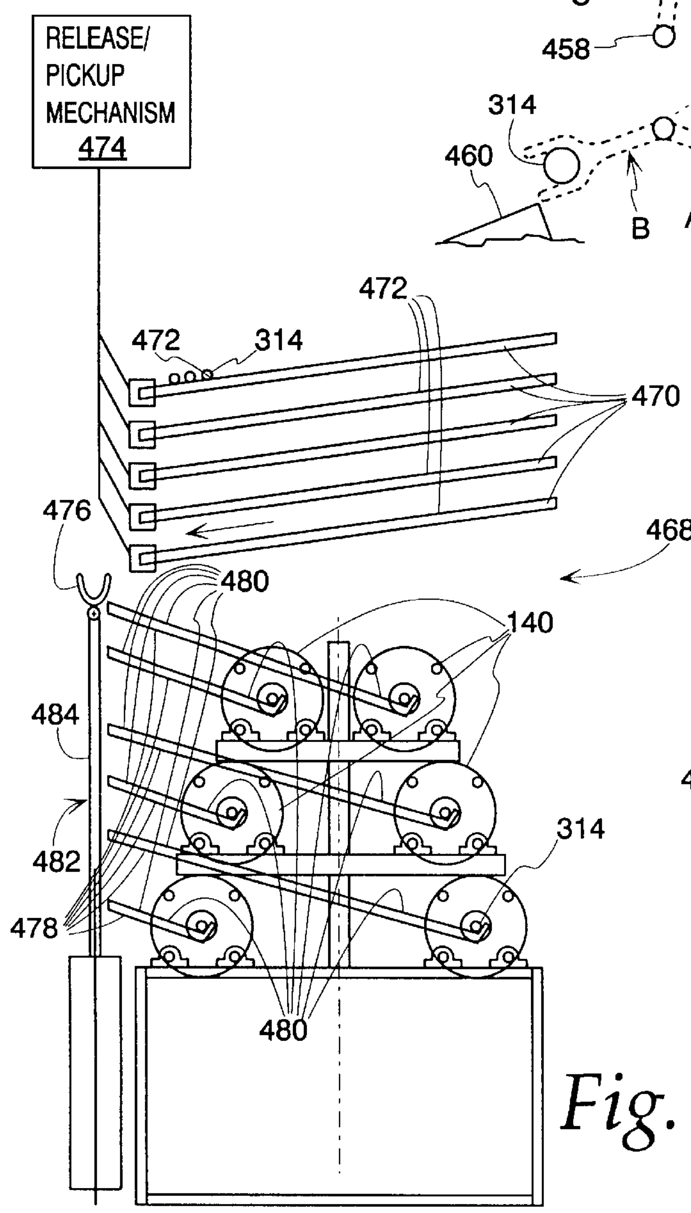

Fig. 21

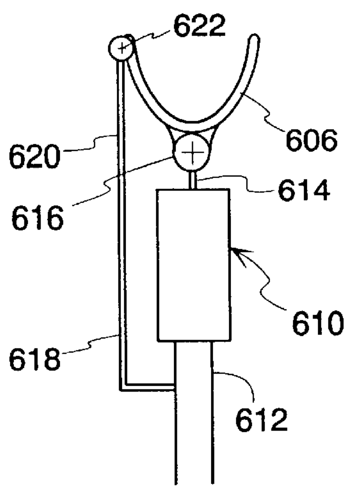

Fig. 30

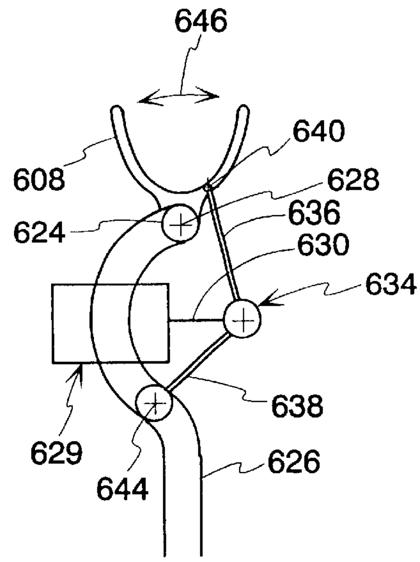

Fig. 31

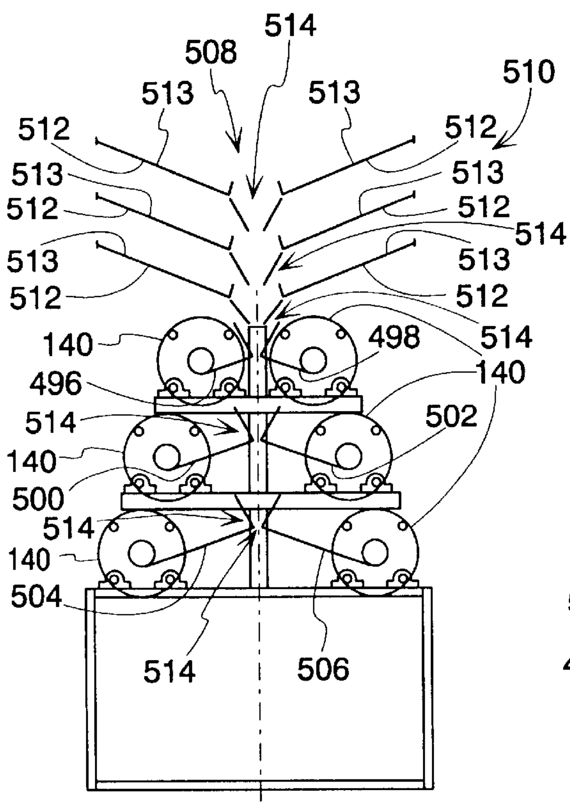

Fig. 23

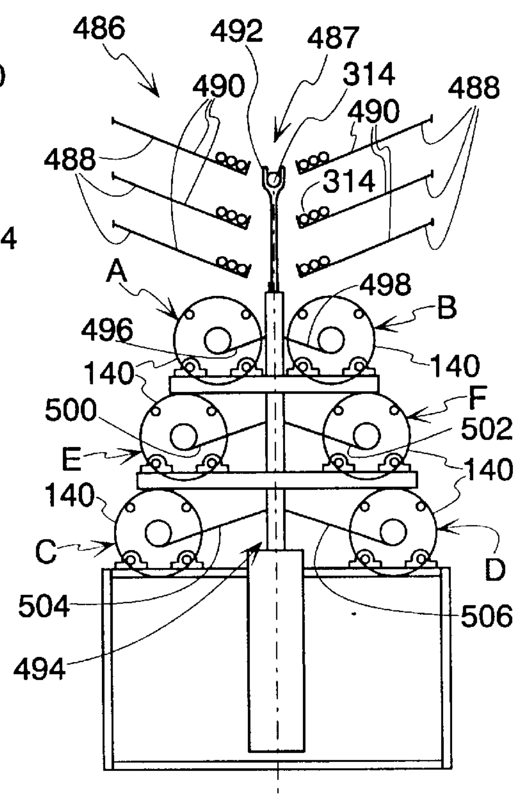

Fig. 22

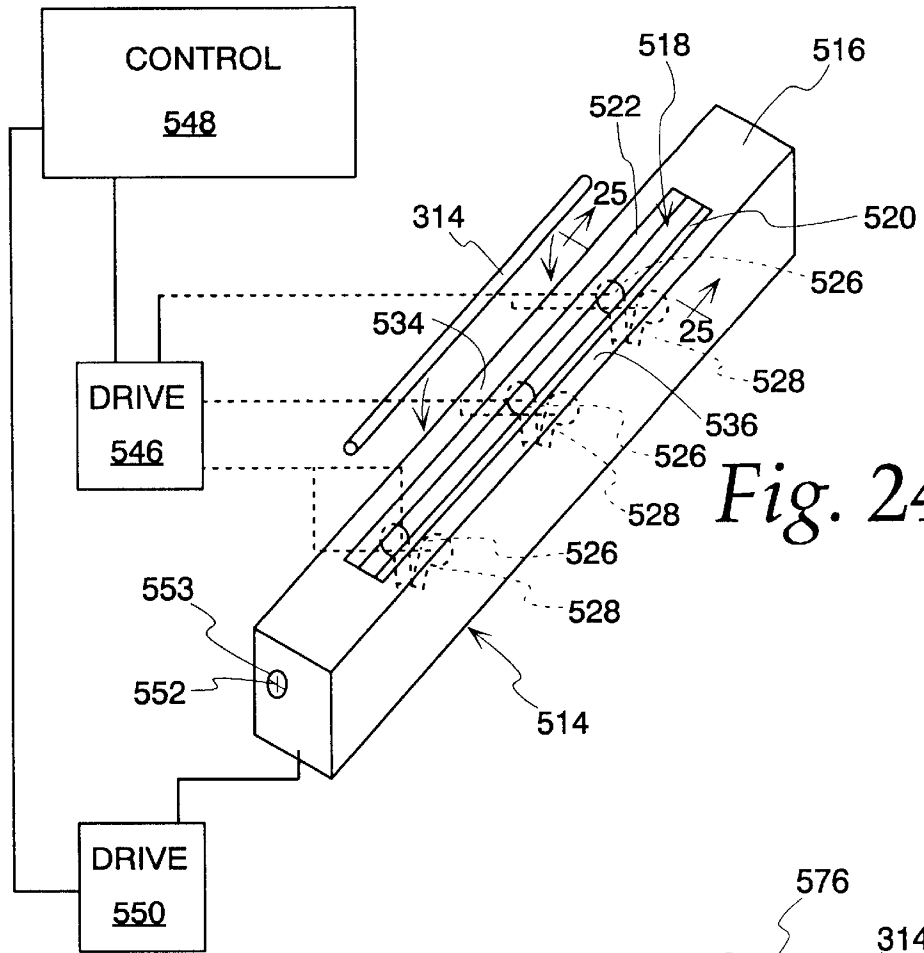

Fig. 24

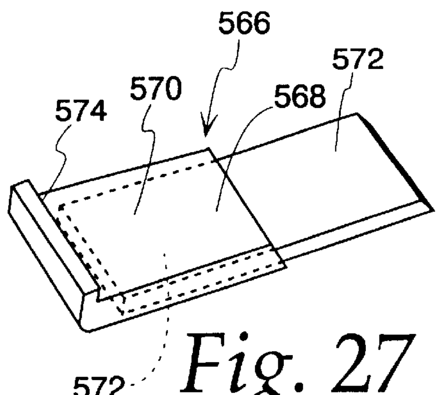

Fig. 27

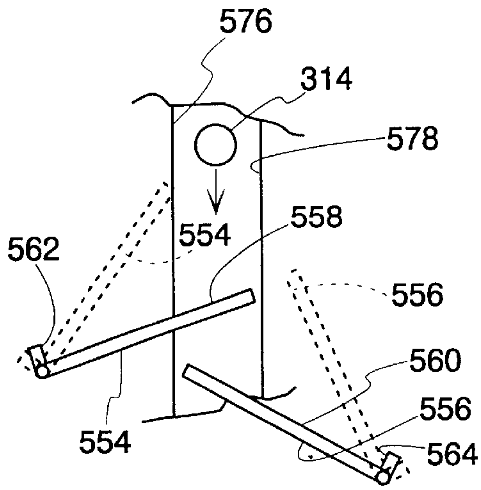

Fig. 26

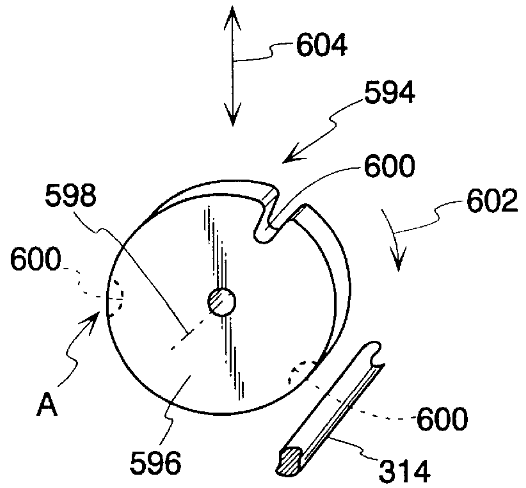

Fig. 29

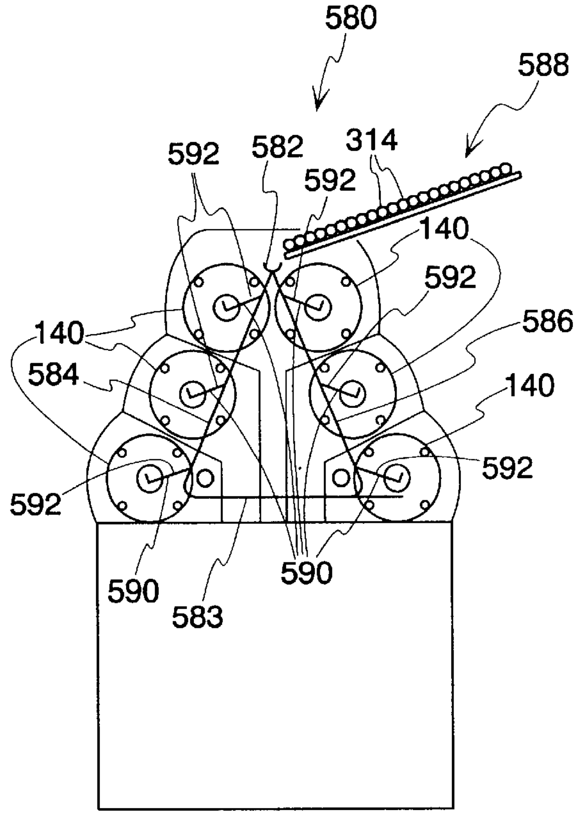

Fig. 28

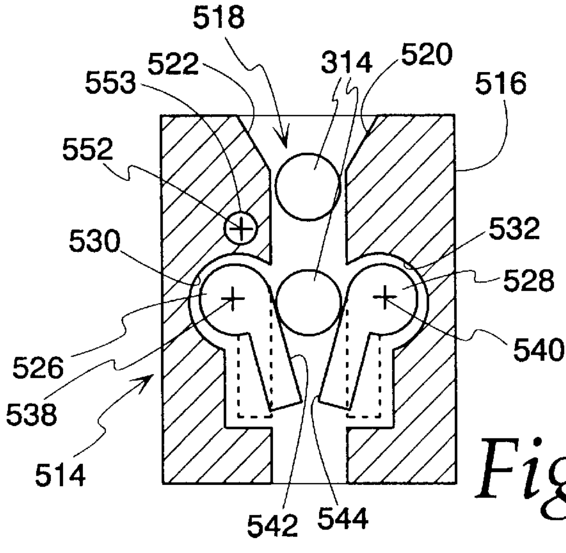

Fig. 25

SYSTEM AND METHOD FOR PROCESSING ELONGATE WORKPIECES

This is a Continuation-in-Part application of Ser. No. 09/633,519, entitled "Machine Tool Assembly and Method of Performing Machining Operations Using the Machine Tool Assembly", filed Aug. 7, 2000.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to machining units for performing machining operations on a workpiece and, more particularly, to a system for processing elongate workpieces utilizing a plurality of the machining units. The invention is also directed to a method for processing elongate workpieces utilizing the system.

2. Background Art

In machining facilities, it is desirable to have the capability to perform multiple machining operations in an efficient manner while minimizing space requirements for the machining equipment. Typically, machine tool assemblies/machining units are arranged on a floor on one level. Most commonly, the machine tool assemblies are oriented horizontally. Floor space planning is carried out with the understanding that the footprint of each horizontally situated machine tool assembly will dictate the amount of floor space required for a particular machine tool assembly. Space above the footprint that is not occupied by the machine tool assembly is for all practical purposes wasted space.

It is known to orient machine tool assemblies vertically to better utilize vertically available space. One example of such an arrangement is shown in my U.S. Pat. No. 6,081,986. While this arrangement does make a better utilization of vertical space, there are drawbacks with this arrangement. First of all, some machine tool assemblies may be more prone to deformation if oriented in other than a horizontal direction. That is, many systems are configured in a pyramidal construction so that stability and accuracy are maintained by building components with decreasing mass from the base up. The vertical orientation of this type of machine tool assembly may cause the misalignment of cooperating components that could detract from system performance.

As with horizontal systems, the space above the vertically oriented individual machine tool assemblies is for all practical purposes wasted.

While ideally many machining operations are performable simultaneously under one roof, the number of such operations is generally limited by the surface area of a floor on which the machine tool assemblies are supported.

SUMMARY OF THE INVENTION

In one form, the invention is directed to a system for processing elongate workpieces. The system consists of a first machining unit for performing a first processing operation on an elongate workpiece that is situated at a first location and a second machining unit for performing a second processing operation on an elongate workpiece that is situated at a second location that is vertically spaced from the first location. The system further consists of a first supply unit on which a plurality of elongate workpieces can be placed in a stored position. A transfer assembly engages an elongate workpiece in a stored position and selectively delivers an elongate workpiece engaged by the transfer assembly to one of the first and second locations.

In one form, the transfer assembly includes a shuttle assembly which is vertically movable between a first

position, from where an elongate workpiece on the shuttle assembly can be delivered to the first location, and a second position, from where an elongate workpiece on the shuttle assembly can be delivered to the second location.

The transfer assembly may further include a first loading unit for directing the elongate workpieces from the stored position to a holding position on the shuttle assembly.

The shuttle assembly may further include an elongate workpiece holder that is repositionable between a conveying position and a first transfer position.

The system may include a first guide surface to which an elongate workpiece in the holding position can be delivered and guided toward the first location with the shuttle assembly in the first position. The first guide surface may decline toward the first location.

In one form, the elongate workpiece holder consists of at least one surface which defines a receptacle for an elongate workpiece in the holding position with the workpiece holder in the conveying position and which guides movement of the elongate workpiece in the holding position onto the first guide surface as an incident of the workpiece holder changing from the conveying position toward the first transfer position.

The elongate workpiece holder may be pivotable between the conveying and transfer positions.

The system may further include a third machining unit for performing a third processing operation on an elongate workpiece that is at a third location spaced from the first and second locations.

In one form, the elongate workpiece holder is repositionable to a second transfer position. The system includes a third guide surface with the at least one surface on the elongate workpiece holder guiding movement of an elongate workpiece in the holding position onto the third guide surface as an incident of the workpiece holder changing from the conveying position toward the second transfer position.

The first and third locations may be at substantially the same height.

The system may further include a guide assembly for guiding vertical movement of the shuttle assembly between the first and second positions.

In one form, the loading unit consists of a pickup shoulder that is moveable between a pickup position and a release position, with the pickup shoulder engaging an elongate workpiece in the stored position and causing movement of an elongate workpiece in the stored position toward the elongate workpiece holder as an incident of the pickup shoulder moving from the pickup position toward the release position.

The shoulder may be pivotable between the pickup and release positions.

In one form, the supply unit consists of an inclined feeding surface along which elongate workpieces are urged by gravitational force toward a pickup location.

In one form, the first loading unit has a blocking surface which blocks movement of an elongate workpiece into the pickup location as the pickup shoulder is moved with a workpiece from the pickup position into the release position.

In one form, there is a stop shoulder at the first guide surface to which an elongate workpiece moving downwardly along the first guide surface abuts to maintain the elongate workpiece which has moved downwardly along the first guide surface consistently in a predetermined position against the stop shoulder.

In one form, the transfer assembly includes a first guide surface which is inclined so as to guide elongate workpieces from the first supply unit toward the first location and a second guide surface which is inclined so as to guide elongate workpieces from the first supply unit toward the second location.

With the shuttle assembly in the first position, a workpiece thereon can be delivered to against the first guide surface for movement thereagainst under gravitational force toward the first location. With the shuttle assembly in the second position, an elongate workpiece thereon can be delivered to against the second guide surface for movement thereagainst under gravitational force toward the second location.

The system may further include a pusher assembly for directing a workpiece into operative relationship with the first machining unit.

In one form, the first machining unit has a rotary operating axis and the pusher assembly pushes an elongate workpiece in a line that is substantially coincident with the rotary operating axis.

The system may include at least one elongate workpiece in a stored position on the first supply unit.

The invention is also directed to a method for processing elongate workpieces, including the steps of: storing a plurality of elongate workpieces on a first supply unit; delivering a first elongate workpiece from the first supply unit to a first location; performing a first processing operation on the first elongate workpiece at the first location; delivering a second elongate workpiece from the first supply unit to a second location that is vertically spaced from the first location; and performing a second processing operation on the second elongate workpiece at the second location.

The method may further include the steps of removing the first elongate workpiece from the first supply unit and blocking removal of another of the plurality of elongate workpieces from the first supply unit.

The step of delivering the first elongate workpiece may involve delivering the first elongate workpiece to against a first inclined guide surface so that the first elongate workpiece moves against the first inclined guide surface under the force of gravity toward the first location.

The step of delivering the second elongate workpiece may involve delivering the second elongate workpiece to against a second inclined guide surface so that the second elongate workpiece moves against the second inclined guide surface under the force of gravity toward the second location.

The step of storing a plurality of elongate workpieces may involve storing a plurality of workpieces on an inclined feeding surface so that the plurality of elongate workpieces are urged by gravitational forces into an accumulated state, one against the other.

The method may further include the steps of guiding the first elongate workpiece from the first supply unit to a first workpiece holder.

The method may further include the step of repositioning the first workpiece holder to thereby direct the first elongate workpiece from the first workpiece holder toward the first location.

The method may further include the steps of directing a third elongate workpiece from the first supply unit to the first workpiece holder and repositioning the first workpiece holder to thereby direct the third elongate workpiece from the first workpiece holder toward a third location.

The method may further include the steps of delivering a third elongate workpiece to the third location and at the third location performing a third processing step on the third elongate workpiece.

The method may include the steps of directing the first elongate workpiece past the first workpiece holder to a second workpiece holder and repositioning the second workpiece holder to thereby direct the first elongate workpiece from the second workpiece holder toward the first location.

The method may include the steps of directing a third elongate workpiece past the first workpiece holder to a second workpiece holder and repositioning the second workpiece holder to thereby direct the third elongate workpiece from the second workpiece holder toward a third location.

The method may include the steps of placing the first workpiece holder in a holding state, directing the first elongate workpiece into a holding position on the first workpiece holder, changing the first workpiece holder from the holding state into a release state, and repositioning the first workpiece holder so that with the first workpiece holder in the release state the first elongate workpiece is directed toward the first location.

The method may include the steps of placing the first workpiece holder into a release state and guiding a third elongate workpiece through the first workpiece holder to a holding position on the second workpiece holder.

The method may further include the step of repositioning the second workpiece holder to thereby direct the third elongate workpiece toward a third location.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a conventional machine tool assembly;

FIG. **2** is a side elevation view of the machine tool assembly of FIG. **1**;

FIG. **3** is a perspective view of a machine tool assembly according to the present invention;

FIG. **4** is a side elevation view of the machine tool assembly of FIG. **3**;

FIG. **5** is a perspective view showing two of the machine tool assemblies of FIGS. **3** and **4** operatively mounted upon one form of base, according to the present invention;

FIG. **6** is a reduced, perspective view of a modified form of base, according to the present invention and with a plurality of machine tool assemblies as in FIGS. **3** and **4** mounted thereto in an operative position;

FIG. **7** is a reduced, perspective view of a further modified form of base, according to the present invention, with a plurality of machine tool assemblies as in FIGS. **3** and **4** in an operative position thereon;

FIG. **8** is a perspective view of a still further modified form of base, according to the present invention, with a machine tool assembly as in FIGS. **3** and **4** in an operative position thereon;

FIG. **9** is a view as in FIG. **8** with a modified form of machine tool assembly, according to the present invention;

FIG. **10** is a reduced, perspective view of a base as in FIG. **7** with a plurality of machine tool assemblies as in FIG. **9** in an operative position thereon;

FIG. **11** is a perspective view of a modified form of base, according to the present invention, with a plurality of modules as in FIG. **9** operatively connected thereto;

FIG. **12** is a perspective view of a still further modified form of base, according to the present invention, with a plurality of modules as in FIG. **9** in an operative position thereon;

FIG. **13** is a flow diagram showing steps that can be used to perform a machining operation according to the present invention and using one of the inventive bases in FIGS. **5–12**;

FIG. **14** is an end elevation view of a system for processing elongate workpieces according to the invention and including a transfer assembly for delivering elongate workpieces in a supply unit to individual machining units shown stacked on a representative base of the type shown in FIG. **12**;

FIG. **15** is an exploded, top, end, and side perspective view of the transfer assembly in FIG. **14**;

FIG. **16** is a side, end, and bottom perspective view of the processing system of FIG. **14**;

FIG. **17** is a bottom perspective view of the processing system taken from the opposite end and same side as in FIG. **16**;

FIG. **18** is an enlarged, fragmentary, cross-sectional view of telescoping cylindrical elements used to selectively vertically reposition a workpiece shuttle assembly on the processing system in FIGS. **14–17**;

FIG. **19** is a fragmentary, end elevation view of a modified form of transfer assembly, according to the present invention, for picking up workpieces from a supply unit and delivering the same to machining units;

FIG. **20** is a fragmentary, end elevation view of a gate system for controllably releasing workpieces from a feeding surface on a supply unit on which a plurality of workpieces are stored;

FIG. **21** is an end elevation view of a system for processing elongate workpieces and including a modified form of transfer assembly, according to the present invention;

FIG. **22** is a view as in FIG. **21** of a still further modified form of transfer assembly, according to the present invention;

FIG. **23** is a view as in FIGS. **21** and **22** of a still further modified form of transfer assembly, according to the present invention;

FIG. **24** is an enlarged, perspective view of a workpiece holder for selectively holding, releasing, and redirecting workpieces on the system in FIG. **23**;

FIG. **25** is a cross-sectional view of the workpiece holder taken along line **25—25** of FIG. **24**;

FIG. **26** is a fragmentary, end elevation view of modified form of transfer assembly, according to the present invention, and including pivotable beams which are selectively moved between operative and bypass positions to intercept downwardly moving workpieces for direction thereof to machining units;

FIG. **27** is a perspective view of a modified form of guide beam that can be reconfigured between operative and bypass positions to selectively intercept or allow passage of downwardly moving workpieces;

FIG. **28** is a view as in FIGS. **21–23** of a still further modified form of transfer assembly, according to the present invention;

FIG. **29** is a perspective view of an alternative form of loading unit for picking up and strategically releasing workpieces for delivery to machining units;

FIG. **30** is a fragmentary, elevation view of a mechanism for selectively tipping a cradle on a workpiece holder, according to the present invention, to selectively deliver workpieces to machining units on different sides of the cradle; and

FIG. **31** is a view as in FIG. **30** of a modified form of a system for tipping a cradle.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring initially to FIGS. **1** and **2**, a conventional, machine tool assembly is shown at **10** and consists of a base **12** which is supported on a subjacent surface **14**. The base **12** in turn supports a machining unit consisting of cooperating machine tool components, in this case a workpiece holder **16** and a machining unit **18** which cooperate to perform a machining operation on a workpiece **20**.

Conventionally, the height of the base **12**, as indicated by the double-headed arrow **22**, is selected to approximate the height of the waist region **24** of an operator **26**, as indicated by the double-headed arrow **28**. The vertical dimension H may be on the order of 30 inches or more. Typically, the machine tool assembly **10** is constructed in a pyramidal fashion, with the components stacked serially, one on top of the other and upon the base **12**, with the stacked components decreasing in mass from bottom to top. The base **12** has a plan profile, in this case defined by the perimeter of an upwardly facing support surface **30**, that is significantly larger than the combined footprint for the workpiece holder **16** and machining unit **18**. By building the components in this manner, structural stability is sought so as to maintain alignment between the workpiece holder **16** and machining unit **18**. At the same time the mass of the base **12** is dictated by the height requirements to situate the workpiece holder **16** and machining unit **18** at the waist region of the operator **26**.

The drawback with the large mass of the base **12** is that the base **12** becomes prone to deformation as it is heated during machining operations. While the large size base **12** does give structural stability, it is also more prone to thermal deformation, which may compromise the alignment between the workpiece holder **16** and machining unit **18**.

In FIGS. **3–8**, one form of machine tool assembly, according to the present invention, is shown at **40**. The machine tool assembly consists of a machining unit consisting of a workpiece holder **42** and a machining component **44** which are supported in operative relationship by a primary base **46**. The primary base **46** may have the same footprint as the base **12**, previously described with respect to the machine tool assembly **10**, but has a vertical dimension H1, indicated by the double-headed arrow **48**, that is less than the height H of the base **12**. For example, the height H1 of the primary base **46** may be on the order of 24 inches or less.

It should be understood that the particular machining components shown are only exemplary in nature. The inventive concept can be practiced with virtually any type of machine tool components capable of performing any machining operation.

In one form, the machine tool assembly **40**, as seen in FIG. **8**, can be supported upon a secondary base **50** which includes a frame **52** consisting of uprights **54** united by a horizontal cross piece **56**. Each upright **54** has an enlarged bottom **58** which bears on a subjacent support surface **60**. A platform element **62** defines an upwardly facing surface **64** to bear on a bottom surface **66** of the primary base **46**. With the primary base **46** supported on the surface **64**, inturned ends **68** of the uprights **54** engage, one each, with an end wall **70, 72** on the primary base **46** for purposes of stability.

With this arrangement, the mass of the primary base **46** can be reduced to make it less susceptible to thermal deformation. By reason of using the secondary base **50**, the machine tool assembly **40** can be situated at a comfortable height for the user **26**.

The low profile machine tool assembly **40** lends itself to various different stacking arrangements. In FIG. **5**, two of the machine tool assembles **40** are shown with their bottom surfaces **66** facially abutted to each other. The abutted machine tool assemblies **40** can in turn be placed upon a secondary base **74** having a peripheral wall **76** bounding a receptacle **78** for collection of machining lubricant and/or particles removed from the workpieces **20** during a machining operation. The peripheral wall **76** has an upwardly facing surface **80** with spaced, parallel surface portions **82**, **84** dimensioned to be spanned by the length L (FIG. **3**) of the primary base **46**. Accordingly, two of the machine tool assemblies **40** can be compactly situated relative to each other upon a single secondary base **74**.

In FIG. **6**, a modified form of secondary base is shown at **90** for supporting a plurality of the machine tool assembles **40** in spaced relationship, both in horizontal and vertical directions. The base **90** consists of a peripheral wall which opens upwardly to define a receptacle **94** for lubricant and/or particles removed from workpieces during the machining process.

The secondary base **90** further includes a frame **95** with a stepped configuration, thereby defining lower, substantially parallel, support surfaces **96**, **98** and an upper support surface **100** spaced above the support surfaces **96**, **98**. The frame **95** spans parallel, spaced surface portions **102**, **104** of an upwardly facing surface **106** at the top of the peripheral wall **92**.

The machine tool assemblies **40** are stacked in an operative position at each side of the frame **95** in like fashion. On one exemplary side of the frame **95**, the lowermost machine tool assembly is situated so that the side surface **108** spans, and is supported by, the surface portions **102**, **104** on the peripheral wall **92** with the bottom surface **66** facially abutted to an upwardly extending surface **110** on the frame **95**.

The superjacent machine tool assembly **40** has its side surface **108** abutted to the support surface **98** and its bottom surface **66** abutted to an upwardly extending surface **112** on the frame **95**. Two of the machine tool assemblies **40** are abutted as in FIG. **5** and supported on the surface **100** at the top of the frame **95**.

With this arrangement, there is an efficient utilization of space vertically above the lowermost machine tool assemblies **40**. With a staggered horizontal arrangement, the machine tool assemblies **40** may be in partial vertical coincidence. A single receptacle **94** defined by the peripheral wall **92** may be used for the multiple machine tool assemblies **40**.

In FIG. **7**, a modified form of secondary base is shown at **120** and consists of at least one frame **122** which defines a series of horizontally and vertically spaced compartments **124**, each designed to receive a machine tool assembly **40** either in a normal horizontal relationship or with the machine tool assembly **40** reoriented from the horizontal position shown. The frame **122** can be made from tubular material or other material, with each compartment including spaced platform elements **126**, **128**, each having an upwardly facing surface **130**, **132**, which surfaces are bridged by the bottom surface **66** of the primary base **46**. The ends of the compartments **124** are each bounded by a part of the frame **122** that extends fully around an operating axis for the machine tool assembly **40** therewithin.

In FIGS. **9–12**, the invention is described with respect to a modified form of machine tool assembly, the details of which are described in a separate, application, Ser. No. 09/633,519, filed Aug. 7, 2000, which is incorporated herein by reference. Briefly, as seen most clearly in FIG. **9**, the machine tool assembly **140** consists of a caged module defined by a series of end supports **142**, **144**, **146**, **148** which are united by bar-shaped, elongate, parallel, reinforcing elements **150**, **152**, **154**, **156**, each of which extends fully through, and is connected to, the end supports **142**, **144**, **146**, **148**. Between adjacent end supports **142**, **144**, **146**, **148** are a series of compartments/working spaces **158**, **160**, **162**, within which a machining unit, consisting of machine tool components, **164** can be mounted. Again, the particular nature of the machining unit is not critical to the present invention, as the inventive concept can be used with virtually any type of machine tool configuration.

In FIG. **9**, the machine tool assembly **140** is shown mounted to the secondary base **150**, previously described. The end supports **142**, **148** are spaced to bear against the upwardly facing platform surface **64**.

In FIG. **11**, a plurality of machine tool assembles **140** are shown mounted to a secondary base **166** which includes a peripheral wall **168** bounding a receptacle **170** for the collection of lubricant and/or particles removed from workpieces by machining. The secondary base **166** includes a frame **172** with spaced frame parts **174** of like construction. Each frame part **174** consists of spaced uprights **176**, **178** joined by a cross piece **180**. A single upright **182** projects vertically from the horizontal center of the cross piece **180**. The uprights **176**, **178** are supported on an upwardly facing surface **184** at the top of the peripheral wall **168**. The uprights **176**,**178** on each frame part **174** are supported on parallel, spaced, surface portions **186**, **188** which are spaced from each other a distance equal to the spacing between the endmost end supports **142**,**148** on each machine tool assembly **140**.

Accordingly, two machine tool assembly modules **140** are supported on the surface portions **186**, **188** through the end supports **142**, **148**, which are abuttable thereto. Each of these machine tool assemblies **140** is abuttable, one each, to the uprights **176**, **178**.

The cross pieces **180** have upwardly facing surfaces **190** to each engage one of the end supports **142**, **148** to support the machine tool assemblies **140** at each side of the uprights **182**.

Removable connectors **192**, each having a U shape with projecting legs **194**, **196**, are useable to anchor the machine tool assemblies **140** to the secondary base **166**. As shown, the connectors **192** are pressed into registrable openings in the end supports **142**,**148** on the lowermost machine tool assemblies **140** and in the peripheral wall **168** and uprights **176**,**178**. Like connectors **192** are used to connect the end supports **142**, **148** on the uppermost machine tool assemblies **140** to the cross piece **180** and upright **182**.

In FIG. **12**, a modified form of secondary base is shown at **198**. The secondary base **198** has the same general construction as the secondary base **166** with the exception that a frame **200** has frame parts **202**, **204** with an additional cross piece **206** and additional depending uprights **208**, **210** which thereby produce an additional step for the inclusion of two additional machine tool assemblies **140**. The length L1 of the peripheral wall **212** defining a receptacle **214** for lubricant/particles from machined workpieces is extended to accommodate the additional machine tool assemblies **140**.

In FIG. **10**, the secondary base **120**, previously described with respect to FIG. **7**, is used to support the machine tool assemblies **140** in their operative position in vertically overlying relationship in columns and in horizontally spaced

relationship in rows. The surfaces **130,132** are spaced to match the spacing of the end supports **142, 148** which bear thereagainst with the machine tool assemblies **140** in the operative position within the compartments **124**.

Referring to FIGS. **10** and **13**, one exemplary method of using the invention to perform a machining operation will be described. The machine tool assemblies **140** may initially be in the operative position shown in FIG. **10** or in a storage position. A lift, which may be a crane **216**, or the like, removes the machine tool assemblies **140**, one by one, from the compartments **124** and delivers the same to a first workpiece loading location **218**. At the loading location, workpieces can be placed into an operative position to thereby prepare the machine tool assemblies for the performance of a machining operation. Once the machine tool assembly **140** is prepared to machine the workpiece thereon, the machine tool assembly **140** with the loaded workpiece can be lifted by the crane **216** and placed in one of the compartments **124**, whereupon a machining operation is performed. The machined workpiece can then be removed by either removing the machine tool assembly **140** from its compartment and thereafter removing the workpiece, or by removing the workpiece from the machine tool assembly **140** with the machine tool assembly **140** in the compartment **124**.

With this arrangement, efficient vertical space utilization is possible. Multiple machining operations can be performed in a coordinated fashion and simultaneously for efficient machining.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Another aspect of the invention is the provision of a transfer assembly which allows controlled delivery of elongate workpieces from a supply thereof selectively to different machining units, as on the machining tool assemblies **140**, for performance of desired processing operations thereon. One form of transfer assembly, according to the present invention, is shown at **300** in FIGS. **14–17** in association with machine tool assemblies **140** mounted on a frame **200**, and in turn upon a secondary base **198** of the type shown in FIG. **12** and described in detail above. It should be understood that the transfer assembly **300** does not depend either upon the nature of the machining units that are part of the machine tool assemblies **140** or the precise stacking arrangement. The embodiment in FIGS. **14–17** is but exemplary of one particular environment for the inventive transfer assembly.

The transfer assembly **300** consists of at least one, and in this case six, supply units **302, 304, 306, 308, 310, 312**, each having a similar construction and designed to hold a plurality of elongate workpieces **314**. Exemplary supply unit **308** has an inclined feeding surface **316** defined cooperatively by spaced, elongate beams **318, 320**. The elongate workpieces **314** are guided by the feeding surface **316** under the force of gravity into an accumulated state, one against the other. The most downstream workpiece **314** assumes a pickup position.

Workpieces of different diameter, length, and composition can be mixed on the various supply units **302, 304, 306, 308, 310, 312**. The transfer assembly **300** is constructed so that the workpieces on each supply unit **302, 304, 306, 308, 310, 312** can be picked up, one by one, and selectively delivered to any of six different locations, corresponding to an operating position on a machining unit on each machine tool assembly **140**.

The transfer assembly **300** consists of a shuttle assembly **324** which is guided in vertical movement by a guide assembly **326**, in this case consisting of spaced, vertical columns **328, 330** with vertically extending slots **332, 334** to accommodate rails **336, 338**. The rails **336, 338** are guided vertically within the slots **332, 334** to allow the shuttle assembly **324** to be placed in three different workpiece pickup positions and three different workpiece delivery positions, as hereinafter described. More particularly, the shuttle assembly **324** consists of a main frame **340** which is fixed to the rails **336, 338**. The main frame **340** and rails **336, 338** thus move together as a unit guidingly in a vertical direction.

The main frame **340** supports a repositionable workpiece holder **342**. The workpiece holder **342** defines a cradle with a generally U-shaped, upwardly opening surface **344** with a base surface portion **346** defining a receptacle and spaced leg portions **348,350** projecting from the base surface portion **346**. The workpiece holder **342** has spaced ears **352, 354** depending from the surface **344** and connected to the main frame **340** by pins **356, 358** for pivoting movement about a horizontally extending axis **360**.

Actuator cylinders **362, 364** are connected between the main frame **340** and workpiece holder **342**. Operation of the cylinders **362, 364**, to vary the effective length thereof, causes pivoting of the workpiece holder **342** about the axis **360** between a first transfer position, as shown at the bottom of FIG. **15**, and a second transfer position, as shown in FIG. **16**. The workpiece holder **342** is in a conveying/holding position between the first and second transfer positions. A workpiece **314** resides within the upwardly opening receptacle defined by the base surface portion **346** with the workpiece holder **342** in the conveying/holding position.

The vertical position of the shuttle assembly **324** is controlled by extensible cylinders **366, 368**, associated one each with the columns **328, 330**. The rail **336** has a stub projection **370** which is attached to the free end **372** of the cylinder **366**. A similar stub projection **374** on the rail **338** is connected to the end **376** of the rail **338**. The cylinders **366, 368** have repositionable rods **378, 380**, respectively. With the cylinder ends remote from the ends **372, 376** fixed relative to the beams **328, 330**, retraction of the rods **378, 380** causes a corresponding downward movement of the rails **336, 338** and main frame **340** attached thereto. Extension of the rods **378, 380** produces the opposite result.

Extension of the cylinder rods **378, 380** places the shuttle assembly **324** in a first pickup position as shown at "A" in FIG. **14**. In this position, workpieces can be transferred from either of the supply units **302, 308** into the receptacle at the base surface portion **346**. The shuttle assembly **324** can be controllably repositioned by operating the cylinders **362, 364** to place the shuttle assembly **324** into second and third different pickup positions. In the second pickup position, the shuttle assembly **324** is situated relative to the supply units **304, 310** in the same manner as it is shown situated relative to the supply units **302, 308** in FIG. **14**. In the third pickup position, the shuttle assembly **324** is situated relative to the supply units **306, 312** in the same manner as is situated relative to the supply units **302, 308** in FIG. **14**.

With the shuttle assembly **324** in the first pickup position, shown in FIG. **14**, workpieces **314** can be delivered thereto from either supply unit **302, 308** in a similar fashion. This process will be described for transfer of workpieces **314** from a stored position on representative supply unit **308**. To effect this transfer, a loading unit **382** is utilized. The loading unit consists of a body **384** defining pickup shoulders **386**

which are pivotable about the axis of a pin **388** between a pickup position, as shown for the corresponding loading unit **382** on the supply unit **310**, therebelow, and a release position, shown for the loading unit **382** on the supply unit **308** in FIG. **14**. In the pickup position, the shoulder **386** resides beneath the most downstream workpiece **314** at a pickup location. The workpiece at the pickup location is blocked from further downward shifting by a pickup shoulder **390**.

The loading unit **382** is pivoted in the direction of the arrow **392**, thereby causing movement of the elongate workpiece from the pickup location toward the workpiece holder **342**. As the pickup shoulder **386** approaches the release position, the pickup shoulder **390** is in a declined orientation so that the workpiece **314** held by the workpiece holder **342** moves under its own weight guidingly down the surface of the pickup shoulder **390** to the receptacle **346** on the workpiece holder **342** to the conveying/holding position.

By then retracting the rods **378**, **380**, the shuttle assembly **324** can be moved downwardly to any of three delivery/release positions. Two such positions are shown in FIG. **14**, with the third residing between the first two. With the shuttle assembly **324** in the topmost delivery/release position shown in FIG. **14**, the work piece **314** carried by the workpiece holder **342** resides above the upper edges **394** of three guide beams **396** associated with the machine tool assembly **140** identified at “A” and corresponding upper edges **398** associated with three guide beams **400** associated with the machine tool assembly identified at “B”. The guide beams **396** have guide surfaces **402** along which workpieces are guided downwardly under gravitational force to against stop shoulders **404** angularly disposed to the guide surfaces **402**. With a workpiece **314** nested at the juncture of the guide surfaces **402** and stop shoulders **404**, the central axis of the workpiece is coincident with a central operating axis **406** for the machine tool **140** at “A”. A pusher assembly **408** is operable to advance the operative workpiece **314** along the axis **406** to a first location wherein it can be grasped by a spindle on the machining unit **140** at “A” that is driven in rotation by a motor **412** through a power transmission belt **414**.

With the shuttle assembly **324** in the top delivery/release position of FIG. **14**, and the workpiece holder in the conveying/holding position, operation of the cylinders **362**, **364** pivots the workpiece holder **342** to the second transfer position of FIG. **17**, whereupon the surface of the leg portion **348** declines to guide the workpiece **314** in the conveying/holding position downwardly to the guide surfaces **402**.

Opposite pivoting of the workpiece holder **342** to the first transfer position is carried out to cause the workpiece **314** in the conveying/holding position to be directed by the surface of the leg portion **350** to, and guidingly down, guide surfaces **416** on the guide beams **400** to against stop shoulders **418** corresponding to the stop shoulders **404**. The workpiece **314** nested at the juncture of the guide surfaces **416** and stop shoulders **418** has its central axis coincident with the central operating axis **420** of the machining unit on the machine tool assembly **140** at “B” in FIG. **14**. A pusher assembly **422** operates like the pusher assembly **408** to advance the operative workpiece **314** into a location wherein it is operatively held by a spindle **426** on the machining unit **140** at “B”.

The shuttle assembly **324** is movable by operation of the cylinders **366**, **368** to be placed selectively in the second and third delivery/release positions. The by third delivery/release position for the shuttle assembly **324** is as shown in FIG. **14**. In that position, the workpiece holder **342** cooperates with guide beams **428**, **430** to selectively deliver workpieces to an operative location with machining units at “C” and “D”, respectively, in FIG. **14**. With the shuttle assembly **324** approximately midway between the first and second delivery/release positions in FIG. **14**, the workpiece holder **342** cooperates with guide beams **432**, **434** to controllably direct workpieces **314** to an operative location with respect to the machine tool assemblies **140** at “E” and “F” in FIG. **14**.

In order to reduce the overall height of the transfer assembly **300**, the cylinders **366**, **368** can be made with a telescoping construction, as shown in FIG. **18**, including multiple telescoping parts **436**, **438**, **440**.

The entire processing system, as described above, can be automatically programmed and operated through a central controller **442**. The central controller **442** can be programmed to coordinate operation of the six loading units **382**, the actuating cylinders **362**, **364**, the pusher assemblies **408**, **422**, and the six machine tool assemblies **140** to selectively and serially deliver work pieces **314** for coordinated processing by the six machining units on the machine tool assemblies **140**.

The invention contemplates many variations from the basic structure described above. Some representative variations contemplated will be described below.

In FIG. **19**, a modified form of workpiece holder is shown at **444** having a generally “Y”-shaped construction. The workpiece holder **444** has a receptacle **446** for a workpiece **314**. The workpiece holder **444** is pivotable about a pin **458** between first and second transfer positions “A”, “B”, corresponding to the transfer positions for the previously described workpiece holder **342**. Between the transfer positions, the workpiece holder **444** assumes an upright conveying/holding position as shown at “C”. The workpiece holder **444** is also pivotable about the pin **458** from the conveying/holding position to a pickup position “D”.

With this arrangement, the workpiece holder **444** can be advanced upwardly in the direction of the arrow **450** from the “C” position and pivoted to the “D” position to advance between the beams **452** (one shown). The beams **452** have inclined feeding surfaces **454** which guide the workpieces **314** into an accumulated position against a pickup shoulder **456**. Continued upward movement of the workpiece holder **444** causes the most downstream workpiece **314** to be advanced into the receptacle **446** and causes the workpiece holder **444** to advance the workpiece **314** that is picked up upwardly past the pickup shoulder **456**. The workpiece holder **444** can then be pivoted to the “E” position and advanced downwardly to thereafter be moved into either of the laterally spaced transfer positions to deliver the carried workpiece **314** to guide surfaces **458**, **460** through which the workpieces **314** are directed to spaced machine tool assemblies **140**. The arrangement in FIG. **18** obviates the need to use an independent loading unit as previously described.

In a further modification, shown in FIG. **20**, a retractable gate element **462** can be used to define a pickup shoulder **464** at the base of a feeding surface **466**. By controllably retracting the gate element **462** to the dotted line position, the most downstream workpiece **314** can be released from a stored position for advancement toward a machining unit through any structure as described either above or below.

In FIG. **21**, another modified form of transfer assembly is shown at **468**. The transfer assembly **468** has a supply unit with a series of vertically spaced beams **470** with inclined feeding surfaces **472**. Through an appropriate release/pickup

mechanism **474**, the workpieces **314** can be delivered one-by-one to a workpiece holder **476** that is capable of vertically repositioning to selectively align at the top of beams **478**. The beams **478** have guide surfaces **480** onto which the workpiece holder **476** deposits a workpiece **314** for guided movement to the machine tool assemblies **140**. The workpiece holder **476** is mounted to a cylinder **482**. By reason of extending and retracting a rod **484** on the cylinder, vertical repositioning of the workpiece holder **476** is effected. The workpiece holder **476** can release the carried workpiece **314** at the desired guide surface **480** through any appropriate mechanism, such as those described above, below, or otherwise known to those skilled in the art. With the transfer assembly **468**, delivery of workpieces **314** to all six of the machine tool assemblies **140** can be effected from one side thereof.

A further variation of the transfer assembly, according to the present invention, is shown at **486** in FIG. **22**. The transfer assembly **486** consists of a supply unit at **487** having guide beams **488** with feeding surfaces **490** that converge toward a workpiece holder **492**. The workpiece holder **492** is carried on a cylinder **494**. By operating the cylinder **494**, the workpiece holder **492** can be selectively placed in any of the three pickup positions to receive a workpiece **314** from any one of the feeding surfaces **490** on the supply unit **487**. Workpiece transfer from the supply unit **487** to the workpiece holder **492** in a conveying/holding position can be accomplished by any means heretofore described, described hereinbelow, or otherwise known to those skilled in the art.

With the workpiece **314** in the conveying/holding position, a telescoping rod **494** on the cylinder **494** can be controllably extended and retracted to align the workpiece holder **492** at any of three different delivery/release positions at any of the three rows of machine tool assemblies **140**, i.e. A,B; E,F; C,D. At the uppermost delivery/release position, the workpiece holder **492** resides between guide beams **496**, **498**, which incline toward the central operating axis for the machine tool assemblies at “A” and “B”, respectively. By selectively repositioning the workpiece holder **492**, through pivoting or otherwise, to either of first and second transfer positions corresponding to those previously described, the workpiece **314** in the conveying/holding position can be transferred to the guide beams **496**, **498** for delivery as into coaxial relationship with the central operating axis for the machine tool assemblies at “A”, “B”. Like beams **500, 502** are associated with the machine tool assemblies “E”, “F”, with guide beams **504**, **506** similarly associated with the machine tool assemblies “C”, “D”.

In FIGS. **23–25**, a further modified form of transfer assembly, according to the present invention, is shown at **508**. The transfer assembly **508** consists of a supply unit **510** with guide beams **512** having converging feeding surfaces **513** as on the supply unit **487** in FIG. **21**. The transfer assembly **508** utilizes the same arrangement of guide beams **496**, **498**, **500**, **502**, **504**, **506** associated with the machine tool assemblies **140**, as in FIG. **22**.

Instead of a single workpiece holder, such as the workpiece holder **492**, the intransfer assembly **508** utilizes multiple workpiece holders **514**. Each workpiece holder consists of a frame **516** with a pass through opening **518** for a workpiece **314**. The entry to the opening **518** has converging surfaces **520**, **522** which guide a downwardly moving workpiece **314** into the through opening **518**.

The workpiece holder **514** has a plurality, and in this case three, pairs of cooperating holding elements **526**, **528**. The holding elements **526**, **528** are mounted in cutouts **530**, **532** within spaced walls **534**, **536** bounding the through opening **518**. Each of the holding elements **526**, **528** has a generally L-shaped construction. The holding elements **526**, **528** are pivotable about parallel axes **538**, **540** between the solid line position, representing a holding state for the workpiece holder **514**, and a dotted line position, representing a release state for the workpiece holder **514**. In the holding state, the holding elements **526,528** are situated so that the edges **542**, **544** thereon extend into the opening **518** so as effectively reduce the dimension of the opening **518** so that the passage of a workpiece **314** therethrough is prevented. In effect, the workpiece **314** becomes releasably clamped between the holding elements **526**, **528**. With the workpiece holder **514** in the release state, the holding elements **526**, **528** are in the dotted line position and a workpiece **314** is allowed to pass unobstructedly through the opening **518**.

An appropriate drive **546** is operable through a control **548** to change the state of the workpiece holder **514** between the holding and release states. A separate drive **550** is operable to rotate the entire workpiece holder **514** around an eccentric pivot axis **552** defined by a mounting pin **553**.

In operation, workpieces **314** are selectively released from the supply unit **510** into the immediately adjacent workpiece holder **514**. Through the control **548**, the states of the holding elements **526**, **528** in the vertically arranged group of workpiece holders **514** are coordinated so that a workpiece **314** is held and released to ultimately be held in the transfer position between one of the guide beams **496**, **498**, **500**, **502**, **504**, **506** adjacent to the machining unit at which the workpiece is to be delivered. At the point of delivery, the receiving workpiece holder is in the holding state. By then pivoting the workpiece holder **514** about the axis **552**, the through opening **518** can be oriented so that a workpiece in the conveying/holding position is released to allow the held workpiece **314** to move guidingly under its own weight onto the appropriate guide beam **496**, **498**, **500**, **502**, **504**, **506** and thereagainst to the selected machining unit A, B, C, D, E, F.

As just one example, a workpiece **314** from the uppermost guide beam **512** can be transferred to the workpiece holder **514** in a receiving position thereadjacent. The receiving workpiece holder **514** can either be in the holding state or in the release state. Eventually, the workpiece holder **514** must be placed in the release state to allow the workpiece **314** to travel through the two underlying workpiece holders **514** to the workpiece holder **514** at the location where it can be transferred, by pivoting of the workpiece holder **514**, to the desired machining unit **140**.

In FIG. **26**, a modified form of transfer assembly, according to the present invention, is shown. In this embodiment, guide beams **554**, **556**, corresponding to the guide beams **496**, **498**, **500**, **502**, **504**, **506**, are pivotably mounted between solid line operative positions and phantom line by-pass positions. In the operative position, guide surfaces **558,560** are situated to intercept a downwardly moving workpiece **314**. In the bypass position, the guide surfaces **558**, **560** are moved out of the path of the downwardly moving workpieces **314**. If the guide beam **554** is placed in the by-pass position, the workpiece **314** will be picked-up by the guide surface **560** of the beam **556** with the beam **556** in the operative position. Similarly, if the guide beam **554** is in the operative position, the workpiece **314** will be intercepted by the guide surface **558**. The guide beams **554**, **556** have stop shoulders **562**, **564**, respectively, to which downwardly moving workpieces **314** on guide surfaces **558**, **560** abut.

As an alternative to pivotably repositioning the entire guide beam **554**, **556** between operative and by-pass

positions, each guide beam can be reconfigurable such as the guide beam **566** in FIG. **27**. The guide beam **566** has an upper guide surface **568** defined by telescoping parts **570**, **572**. A stop shoulder **574** intercepts downwardly moving workpieces along the guide surface **568**. The guide beam **566** is shown in the operative position in solid lines. With the part **572** retracted to the dotted line position, the guide beam **566** is placed in the bypass position. That is, its effective length is such that it does not reside in the path of a downwardly moving workpiece **314** as to cause diversion thereof to a machining tool on a machine tool assembly **140**.

In the embodiment shown in FIGS. **26** and **27**, to control workpiece movement, it may be desirable to provide guide walls **576**, **578**, which confine horizontal shifting of downwardly moving workpieces **314**. It is possible with these embodiments to use any type of supply unit and any appropriate structure for releasing the individual workpieces from the supply unit.

A variation of this system is shown in FIG. **28** wherein a transfer assembly **580** is shown consisting of a workpiece holder **582** which is guidable, as by an endless member **583** trained in a predetermined path, selectively from an apex position, as shown in FIG. **28**, along the vertically extending legs **584**, **586** of an inverted V-shaped path. Once the workpiece **314** is transferred from a supply unit **588** to the workpiece holder **582**, the workpiece holder **582** can be selectively moved along either of the legs **584**, **586** to a desired delivery position adjacent to one of the machining units on a machine tool assembly **140** to which a transfer is to be made. Each machine tool assembly **140** has an associated guide beam **590** with an inclined guide surface **592** to accept a workpiece **314** from the workpiece holder **582** and guide the same into the desired operative relationship with a machining unit.

As an alternative, the guide beams **590** could be reconfigurable between operative and bypass positions. The workpiece holder **582** could, from the apex position shown, deliver a workpiece down either leg **584**, **586**, to be picked up by the first operatively positioned guide beam **590**.

Another variation to the basic transfer assembly is shown in FIG. **29**. A loading unit is shown at **594** and consists of a disc-shaped element **596** which is pivotable about an axis **598** between a pickup position, shown in solid lines, and a release position. In the pickup position, a notch **600** is positioned to engage a workpiece **314** at a pickup location on a supply unit. Once this occurs, the element **596** can be pivoted about the axis **598** in the direction of the arrow **602** until the notch **600** assumes the dotted line position, whereupon the workpiece **314** releases under the force of gravity. The disc-shaped element **596** is rotated oppositely to the direction of the arrow **602** so that the workpiece **314** can be released therefrom at the position “A” shown in FIG. **29**.

The disc-shaped element **596** can be moved vertically, in the direction of the double-headed arrow **604**, to align with different beams to feed the workpieces from a supply to different vertical heights. The same arrangement can be used to pick up workpieces **314** from either horizontal side of the axis **598**.

In FIGS. **30** and **31**, different mechanisms are shown for repositioning a cradle **606**,**608** for a workpiece on a workpiece holder. In FIG. **30**, a cylinder **610** is mounted on a vertically extending support **612**. The cylinder **610** has a rod **614** with an end **616** pivotably connected to the cradle **606**. An L-shaped arm **618** extends from the support **612**. The arm end **620** remote from the support **612** is pivotably connected to the cradle **606**. By selectively extending and retracting the rod **614**, the cradle can be pivoted about an axis **622** to tip a workpiece in a conveying/holding position therein to one side or the other.

In FIG. **31**, the cradle **608** is pivotably connected adjacent to the free end **624** of a support **626**. Through this pivot connection, the cradle **608** is pivotable about an axis **628**. An operating cylinder **629** has a repositionable rod **630** which is pivotably connected at a joint **634** at which link elements **636**, **638** are pivotably connected. The end of the link **636** remote from the joint **634** is connected to the cradle **608** for relative pivoting movement about an axis **640**, which is substantially parallel to the axis **628**. The end of the link element **638** remote from the joint **634** is connected to the support **626** for pivoting movement about an axis **644**.

Extension and retraction of the rod **630** effects a reconfiguration of the linkage made up of the elements **636**, **638** to selectively tip the cradle **608** in opposite directions, as indicated by the double-headed arrow **646**. To accommodate the linkage, the support **626** is made U-shaped in the region at which the cylinder **629** is mounted. This potentially compacts the horizontal space requirements for operation of the cylinder **629** and linkage made up of the link elements **636**, **638**.

It should be understood that while several variations of transfer assemblies according to the present invention have been shown, many of these variations have been intended only to be illustrative. The mechanisms shown in U.S. Pat. No. 5,911,803, as well as those known to persons skilled in the art, could be utilized to make other modifications to the various structures shown.

The foregoing disclosure of specific embodiments is intended to be illustrative of the broad concepts comprehended by the invention.

What is claimed is:

1. A system for processing elongate workpieces, said system comprising:

a first machining unit for performing a first processing operation on an elongate workpiece that is situated at a first location;

a second machining unit for performing a second processing operation on an elongate workpiece that is situated at a second location that is vertically spaced from the first location;

a first supply unit on which a plurality of elongate workpieces can be placed in a stored position; and

a transfer assembly to engage an elongate workpiece in the stored position and selectively deliver an elongate workpiece engaged by the transfer assembly selectively to one of the first and second locations, the transfer assembly comprising first and second inclined surfaces which guide elongate workpieces moving under gravitational forces along the first and second inclined surfaces between the supply toward the first and second machining units.

2. The system for processing elongate workpieces according to claim **1** wherein the transfer assembly comprises a shuttle assembly which is vertically movable between a first position from where an elongate workpiece on the shuttle assembly can be delivered to the first location and a second position from where an elongate workpiece on the shuttle assembly can be delivered to the second location.

3. The system for processing elongate workpieces according to claim **2** wherein the transfer assembly further comprises a first loading unit for directing elongate workpieces from the stored position to a holding position on the shuttle assembly.

4. The system for processing elongate workpieces according to claim **3** wherein the shuttle assembly comprises an elongate workpiece holder that is repositionable between a conveying position and a first transfer position.

5. The system for processing elongate workpieces according to claim **4** wherein the first loading unit comprises a pickup shoulder that is movable between a pickup position and a release position, the pickup shoulder engaging an elongate workpiece in the stored position and causing movement of an elongate workpiece from the stored position toward the elongate workpiece holder as an incident of the pickup shoulder moving from the pickup position toward the release position.

6. The system for processing elongate workpieces according to claim **5** wherein the shoulder is pivotable between the pickup and release positions.

7. The system for processing elongate workpieces according to claim **5** wherein the supply unit comprises an inclined feeding surface along which elongate workpieces are urged by gravitational force toward a pickup location.

8. The system for processing elongate workpieces according to claim **7** wherein the first loading unit further comprises a blocking surface to block movement of an elongate workpiece into the pickup location as the pickup shoulder is moved with a workpiece from the pickup position into the release position.

9. The system for processing elongate workpieces according to claim **2** further comprising a guide assembly for guiding vertical movement of the shuttle assembly between the first and second positions.

10. The system for processing elongate workpieces according to claim **1** further comprising a pusher assembly for directing a workpiece into operative relationship with the first machining unit.

11. The system for processing elongate workpieces according to claim **10** wherein the first machining unit has a rotary operating axis and the pusher assembly pushes an elongate workpiece in a line that is substantially coincident with the rotary operating axis.

12. The system for processing elongate workpieces according to claim **1** further comprising at least one elongate workpiece in a stored position on the first supply unit.

13. A system for processing elongate workpieces, said system comprising:

a first machining unit for performing a first processing operation on an elongate workpiece that is situated at a first location;

a second machining unit for performing a second processing operation on an elongate workpiece that is situated at a second location that is vertically spaced from the first location;

a first supply unit on which a plurality of elongate workpieces can be placed in a stored position; and

a transfer assembly to engage an elongate workpiece in the stored position and selectively deliver an elongate workpiece engaged by the transfer assembly selectively to one of the first and second locations,

wherein the transfer assembly comprises a shuttle assembly which is vertically movable between a first position from where an elongate workpiece on the shuttle assembly can be delivered to the first location and a second position from where an elongate workpiece on the shuttle assembly can be delivered to the second location,

wherein the transfer assembly comprises a first loading unit for directing elongate workpieces from the stored position to a holding position on the shuttle assembly,

wherein the shuttle assembly comprises an elongate workpiece holder that is repositionable between a conveying position and a first transfer position,

the system further comprising a first guide surface to which an elongate workpiece in the holding position can be delivered and guided toward the first location with the shuttle assembly in the first position.

14. The system for processing elongate workpieces according to claim **13** wherein the first guide surface declines toward the first location.

15. The system for processing elongate workpieces according to claim **14** wherein the elongate workpiece holder comprises at least one surface which defines a receptacle for an elongate workpiece in the holding position with the workpiece holder in the conveying position and which guides movement of an elongate workpiece in the holding position onto the first guide surface as an incident of the workpiece holder changing from the conveying position toward the first transfer position.

16. The system for processing elongate workpieces according to claim **15** wherein the elongate workpiece holder is pivotable between the conveying position and the first transfer position.

17. The system for processing elongate workpieces according to claim **15** further comprising a third machining unit for performing a third processing operation on an elongate workpiece that is at a third location spaced from the first and second locations.

18. The system for processing elongate workpieces according to claim **17** wherein the elongate workpiece holder is repositionable to a second transfer position, there is a third guide surface and the at least one surface on the elongate workpiece holder guides movement of an elongate workpiece in the holding position onto the third guide surface as an incident of the workpiece holder changing from the conveying position toward the second transfer position.

19. The system for processing elongate workpieces according to claim **18** wherein the first and third locations are at substantially the same height.

20. The system for processing elongate workpieces according to claim **14** wherein there is a stop shoulder at the first guide surface to which an elongate workpiece moving downwardly along the first guide surface abuts to maintain an elongate workpiece which has moved downwardly along the first guide surface consistently in a predetermined position against the stop shoulder.

21. A system for processing elongate workpieces, said system comprising:

a first machining unit for performing a first processing operation on an elongate workpiece that is situated at a first location;

a second machining unit for performing a second processing operation on an elongate workpiece that is situated at a second location that is vertically spaced from the first location;

a first supply unit on which a plurality of elongate workpieces can be placed in a stored position; and

a transfer assembly to engage an elongate workpiece in the stored position and selectively deliver an elongate workpiece engaged by the transfer assembly selectively to one of the first and second locations,

wherein the transfer assembly comprises a first guide surface which is inclined so as to guide elongate workpieces from the first supply unit toward the first location and a second guide surface which is inclined

so as to guide elongate workpieces from the first supply unit toward the second location.

22. The system for processing elongate workpieces according to claim **21** wherein the transfer assembly further comprises a shuttle assembly which is vertically movable between a first position from where an elongate workpiece on the shuttle assembly can be delivered to against the first guide surface for movement under gravitational force toward the first location and a second position from where an elongate workpiece on the shuttle assembly can be delivered to against the second guide surface for movement thereagainst under gravitational force toward the second location.

23. A method for processing elongate workpieces, said method comprising the steps of:

storing a plurality of elongate workpieces on a first supply unit;

delivering a first elongate workpiece from the first supply unit to a first location by causing the first elongate workpiece to move under gravitational force between the first supply unit toward the first location;

performing a first processing operation on the first elongate workpiece at the first location;

delivering a second elongate workpiece from the first supply unit to a second location that is vertically spaced from the first location by causing the second elongate workpiece to move under gravitational force from the first supply unit toward the second location; and

performing a second processing operation on the second elongate workpiece at the second location.

24. The method for processing elongate workpieces according to claim **23** wherein the step of storing a plurality of elongate workpieces comprises storing a plurality of workpieces on an inclined feeding surface so that the plurality of elongate workpieces are urged by gravitational forces into an accumulated state one against the other.

25. The method for processing elongate workpieces according to claim **24** further comprising the step of guiding the first elongate workpiece from the first supply unit to a first workpiece holder.

26. A method for processing elongate workpieces, said method comprising the steps of:

storing a plurality of elongate workpieces on a first supply unit;

delivering a first elongate workpiece from the first supply unit to a first location;

performing a first processing operation on the first elongate workpiece at the first location;

delivering a second elongate workpiece from the first supply unit to a second location that is vertically spaced from the first location;

performing a second processing operation on the second elongate workpieces at the second location;

removing the first elongate workpiece from the first supply unit; and

blocking removal of another of the plurality of elongate workpieces from the first supply unit.

27. A method for processing elongate workpieces, said method comprising the steps of:

storing a plurality of elongate workpieces on a first supply unit;

delivering a first elongate workpiece from the first supply unit to a first location;

performing a first processing operation on the first elongate workpiece at the first location;

delivering a second elongate workpiece from the first supply unit to a second location that is vertically spaced from the first location; and

performing a second processing operation on the second elongate workpiece at the second location,

wherein the step of delivering the first elongate workpiece comprises delivering the first elongate workpiece to against a first inclined guide surface so that the first elongate workpiece moves against the first inclined guide surface under the force of gravity toward the first location.

28. The method for processing elongate workpieces according to claim **27** wherein the step of delivering the second elongate workpiece comprises delivering the second elongate workpiece to against a second inclined guide surface so that the second elongate workpiece moves against the second inclined guide surface under the force of gravity toward the second location.

29. A method for processing elongate workpieces, said method comprising the steps of:

storing a plurality of elongate workpieces on a first supply unit;

delivering a first elongate workpiece from the first supply unit to a first location;

performing a first processing operation on the first elongate workpiece at the first location;

delivering a second elongate workpiece from the first supply unit to a second location that is vertically spaced from the first location;

performing a second processing operation on the second elongate workpiece at the second location,

wherein the step of storing a plurality of elongate workpieces comprises storing a plurality of workpieces on an inclined feeding surface so that the plurality of elongate workpieces are urged by gravitational forces into an accumulated state one against the other;

guiding the first elongate workpiece from the first supply unit to a first workpiece holder; and

repositioning the first workpiece holder to thereby direct the first elongate workpiece from the first workpiece holder toward the first location.

30. The method for processing elongated workpieces according to claim **29** further comprising the steps of directing a third elongated workpiece from the supply unit to the first workpiece holder and repositioning the first workpiece holder to thereby direct the third elongated workpiece from the first workpiece holder toward a third location.

31. The method for processing elongated workpieces according to claim **30** further comprising the steps of delivering the third elongated workpiece to the third location and at the third location performing a third processing step on the third elongated workpiece.

32. The method for processing elongated workpieces according to claim **29** further comprising the steps of directing the first elongated workpiece past the first workpiece holder to a second workpiece holder and repositioning the second workpiece holder to thereby direct the first elongated workpiece from the second workpiece holder toward the first location.

33. The method for processing elongated workpieces according to claim **32** further comprising the step of placing the first workpiece holder into a release state and guiding a third elongated workpiece through the first workpiece holder to a holding position on the second workpiece holder.

34. The method for processing elongated workpieces according to claim **33** further comprising the steps of

repositioning the second workpiece holder to thereby direct the third elongated workpiece toward a third location.

35. A method for processing elongate workpieces, said method comprising the steps of:

storing a plurality of elongate workpieces on a first supply unit;

delivering a first elongate workpiece from the first supply unit to a first location;

performing a first processing operation on the first elongate workpiece at the first location;

delivering a second elongate workpiece from the first supply unit to a second location that is vertically spaced from the first location;

performing a second processing operation on the second elongate workpiece at the second location,

wherein the step of storing a plurality of elongate workpieces comprises storing a plurality of workpieces on an inclined feeding surface so that the plurality of elongate workpieces are urged by gravitational forces into an accumulated state one against the other;

guiding the first elongate workpiece from the first supply unit to a first workpiece holder,

directing a third elongate workpiece past the first workpiece holder to a second workpiece holder; and

repositioning the second workpiece holder to thereby direct the third elongate workpiece from the second workpiece holder toward a third location.

36. A method for processing elongate workpieces, said method comprising the steps of:

storing a plurality of elongate workpieces on a first supply unit;

delivering a first elongate workpiece from the first supply unit to a first location;

performing a first processing operation on the first elongate workpiece at the first location;

delivering a second elongate workpiece from the first supply unit to a second location that is vertically spaced from the first location;

performing a second processing operation on the second elongate workpiece at the second location,

wherein the step of storing a plurality of elongate workpieces comprises storing a plurality of workpieces on an inclined feeding surface so that the plurality of elongate workpieces are urged by gravitational forces into an accumulated state one against the other;

guiding the first elongate workpiece from the first supply unit to a first workpiece holder;

placing the first workpiece holder in a holding state

directing the first elongate workpiece into a holding position on the first workpiece holder;

changing the first workpiece holder from the holding state into a release state; and

repositioning the first workpiece holder so that with the first workpiece holder in the release state the first elongate workpiece is directed toward the first location.

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